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THE INDIA-RUBBER AND GUTTA PERCHA INDUSTRIES.*

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Lecture I.

THE SOURCES OF INDIA-RUBBER.

India-rubber, or caoutchouc, possesses properties so widely different from those of most other substances, that it became an object of very great interest as soon as it made its appearance in the civilized world, and its industrial importance has rapidly increased as the knowledge of its remarkable characters and manifold applicability has become more extended. At the present time, caoutchouc holds such an important position with regard to the economy of modern arts and manufactures that were it suddenly to be withdrawn from circulation many minor industries would in consequence cease to exist; while numerous large and important branches of handicraft would languish until arrangements could be made to adapt their operations to the altered circumstances.

It is, however, during the last forty years that India-rubber has enjoyed its greatest triumphs as an industrial agent; that is to say, since the art of vulcanization was discovered and perfected by the labors of Charles Goodyear, Thomas Hancock, and others.

The earliest rumor of the existence of caoutchouc reached Europe nearly five hundred years ago; the first visit of Columbus to Hayti having brought to light the fact that the natives of this island were in the habit of making playing balls of an elastic gum. Nothing more appears to have been heard of India-rubber until Torquemada, rather over two hundred and fifty years ago, described the Mexican Indians as not only making playing balls of India-rubber, but also as fabricating helmets, shoes, waterproof fabrics, and other articles of elastic gum. This writer gives some details as to the collection of the juice and the making of various articles from it, thus giving us the first view of the India-rubber manufacture as a branch of industry. We do not hear, however, of samples of India-rubber reaching Europe until long after this, and little more appears to have been learned regarding the substance until the celebrated French naturalist, La Condamine, made a communication to the Academy of Sciences, at Paris, concerning caoutchouc, he having had ample opportunities of studying the subject in Para. In the memoir in question, La Condamine gives very detailed particulars regarding the Para India-rubber tree, the collection and treatment of the juice, and the methods made use of by the natives for the production of various articles of caoutchouc. He tells us that the substance in question was used for making torches, these being only an inch and a half in diameter by two feet long, and yet burning for twelve hours. Again we hear of the use of India-rubber for the making of playing balls, and it appears that the natives were in the habit of using enema or injection bottles made of caoutchouc.

Soon after La Condamine's communication to the Academy of Sciences, samples of India-rubber frequently reached Europe, and scientific men began to make investigations regarding this remarkable body. Between 1760 and 1770 we find Fresneau and Macquer studying the subject, and the last named investigator made tubes and other articles of caoutchouc by dissolving it in ether and coating moulds with the solution, so that a solid skin of caoutchouc should remain adherent to the mould on the evaporation of the solvent.

EARLY MANUFACTURES OF RUBBER.

From this time until the end of the eighteenth century, the India-rubber industry may be considered to have been undergoing its period of gestation, and to have been born with the dawn of the present century. Among the first of the important patents regarding the utilization of caoutchouc is that granted in 1823 to Charles Macintosh, for dissolving the substance in coal oil, or coal naphtha, and the use of this solution as a waterproofing agent. I have here a specimen of such a solution, as now manufactured by Messrs. Charles Macintosh & Co., of Manchester, together with some examples illustrating its uses.

About the same time elastic webbing was first made with threads, cut from the raw rubber, and other minor applications of caoutchouc to the industrial arts were adopted from time to time, until the great discovery of vulcanization inaugurated a new epoch in this branch of industry, rendering it possible to so far alter caoutchouc as to make it capable of resisting, to a great extent, the action of heat on the one hand, and cold on the other hand.

The milky sap of many plants contains caoutchouc, suspended in the form of minute transparent globules, these being frequently as small as $\frac{1}{10000}$ to $\frac{1}{5000}$ of an inch in diameter; but comparatively few plants contain sufficient caoutchouc to render them important sources of this body.

RUBBER BEARING TREES.

The trees which yield the largest supply of the best quality of caoutchouc consist of various species of hevea, which flourish in the Northern districts of South America, especially in the province of Para, some portions of the valley of the Amazon being crowded to an extraordinary extent with heveas. The abundance of the India-rubber trees in Para may be judged of by the fact that this province alone exported seven thousand three hundred and forty tons of caoutchouc in the year 1877; more than half of this being sent to Liverpool.

Among the heveas most productive of caoutchouc may be mentioned the *Hevea brasiliensis*, which flourishes in Para, and yields some of the finest caoutchouc, and often attains a height of sixty to seventy feet, with a diameter of nearly three feet; the *Hevea guianensis* (Fig. 1), a similarly magnificent tree, likewise abundantly productive of caoutchouc, and the *Hevea spruceana*, a smaller tree, which grows almost exclusively in the province of Para.

I now project on the screen a lantern slide representing a forest of heveas, and next I will show you one which will give you some idea of the foliage and flower of the *Hevea guianensis*.

COLLECTION AND COMPOSITION OF RUBBER JUICE.

The operation of collecting the juice is well illustrated by the drawing (Fig. 3) which is now projected on the screen. A series of cuts being made through the bark of the tree, either shells or clay vessels are attached to receive the exuding milky sap, and when sufficient of this has been collected, the operation of drying it is performed as follows: A kind of wooden bat, thinly covered over with clay, is dipped into a pail filled with the juice, and the bat, thus coated, is held over a fire, fed with certain wild nuts, which, in burning, give off abundance of aromatic smoke. The picture now on the screen (Fig. 4) represents this operation, and you will

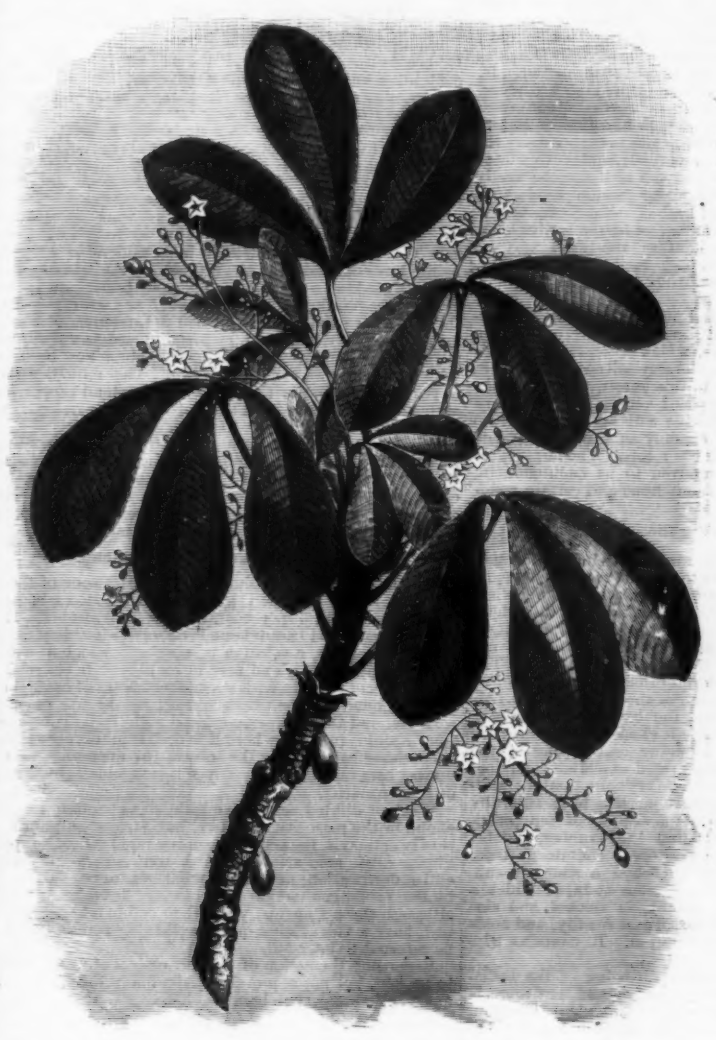


Fig. 1.—HEVEA GUIANENSIS, OR RUBBER TREE.

Fig. 2.—FICUS ELASTICUS; A SPECIMEN GROWING IN THE OPEN AIR AT PARIS.

* A series of six lectures delivered before the Society of Arts, London, 1880.

see that a kind of short chimney is fixed over the fire to lead the smoke compactly upward. As soon as the first layer of juice has become indurated, the bat is again dipped, and the drying operation is repeated; layer after layer being thus dried on the bat, until a thickness of nearly an inch is attained. A knife-cut is now made in the bottle or biscuit of caoutchouc thus obtained, so that it can be removed from the wooden bat, and exposed to the air to become still further indurated. Para caoutchouc, prepared in this manner, has a fragrant aromatic odor, which you can study for yourselves in the samples now before you.

The residues of juice left in the various vessels employed, the scrapings of the incisions, together with other materials, which the ingenious native thinks he can shuffle off on the unsuspecting merchant as caoutchouc, are made into balls, and sold as "negro head." The negro head rubber is frequently made into crude representations of animals, and there are several such works of native art on the table—as, for example, this specimen, which will pass about equally well for a horse, a pig, or a crocodile. For the opportunity of showing you this very fine collection of specimens of raw rubber, I have to thank the Silvertown Company, Messrs. Tuck, Messrs. Macintosh & Co., and others. Your attention will be specially called to some of these shortly.

Here is a piece of Para bottle rubber, which has been boiled for some hours in water, and you see that it is now so far softened as to render it easy to pull asunder the several layers of which it is composed, its laminated structure being thus very well illustrated.

The milky juice of the Para rubber trees, of which you see a specimen before you, has approximately the following composition:

Caoutchouc	33
Albuminous, extractive, and saline matters	12
Water	56
	100

As a rubber producing tree, the *Ficus elastica* stands next in importance of the hevea. The *Ficus elastica* grows abundantly in India and the East Indian Islands, one district in Assam, thirty miles long by eight miles wide, being said to contain forty-three thousand trees, many of them attaining a height of a hundred feet. This tree also grows freely in Madagascar, and it is well known to us as a greenhouse plant. The slide now projected on the screen represents the *Ficus elastica* in its native regions; and I will next show you one illustrating a *Ficus elastica* now growing out of doors in the Parc Monceau at Paris (Fig. 2).

The juice of the *Ficus elastica* contains notably less caoutchouc than that of the American trees, the proportion very often falling as low as 10 per cent. of the juice.

A vine-like plant, the *Urceola elastica*, which grows abundantly in Madagascar, Borneo, Singapore, Sumatra, Penang, and other places, yields a considerable amount of caoutchouc of very good quality, and you will find specimens of the substance from these districts on the table.

Africa yields a considerable quantity of caoutchouc, but generally soft and of inferior quality. It is believed to be yielded by various species of landolphia, ficus, and toxicophlea. Here are some specimens of African rubber. This specimen, representing the quality known as African ball, being tolerably firm in consistency, while the African flake, which you see here, and the African tongue represent the lowest and most viscous qualities of commercial rubber. In order that you may compare the two extremes of quality, I will hand round a specimen of fine Para together with a piece of African tongue.

The commercial value of the various qualities of rubber may be estimated, to a certain extent, by noting the loss which the samples undergo during the operation of washing, which operation will be described in the next lecture; and also by noticing how far the various samples are softened by a long continued gentle heat. Here are some samples which have been heated for some hours in this water oven; you will notice that the African tongue has become almost as soft as treacle, while the Para rubber still retains its form and much of its consistency.

CHARACTERISTICS OF RUBBER.

Caoutchouc is nearly colorless, and when in thin leaves tolerably transparent. It, like very many other substances, contains nothing but carbon and hydrogen, but its properties differ very widely from those of other hydrocarbons almost identical in composition. It has been found to contain in one hundred parts, 12·5 of hydrogen and 87·5 of carbon. Caoutchouc, as might be supposed, burns very readily and leaves no residue; if I set fire to a few ounces, you see how it blazes up. It is soft, and very imperfectly elastic, in the true sense of the term; that is to say, it does not return to its old dimensions after having been considerably stretched. Here is a strip of pure (*i. e.*, unvulcanized) caoutchouc a foot long; you see that I have stretched it to a length of three feet, and, after holding it stretched for a few seconds, I relax it. It now measures, as you see, several inches over the foot. The elasticity of caoutchouc may be enormously increased by vulcanization, as I will illustrate to you in future lectures.

As regards the stretching of India-rubber, there is a point at which it requires a greatly increased force to stretch it, and at this point it seems to become fibrous in texture, as you may perceive, by examining this extended sample by the aid of a magnifying lens. India-rubber has valuable electrical properties, as you are no doubt aware, it being an admirable insulator, and having a great tendency to become electrical by friction.

Freshly cut surfaces of India-rubber cohere very strongly when brought into contact, and this is well illustrated by the old way of making a tube of unvulcanized caoutchouc. You see that I wrap a sheet of caoutchouc round a mandrel, so that the edges project parallel to each other. These parallel edges being cut off by means of scissors, the freshly cut edges adhere, and a perfect tube is the result. Toy balloons are made in a somewhat analogous manner, as I shall illustrate in the next lecture, these being cold vulcanized afterwards.

Either French chalk or soapy water is of constant use in the rubber factories, to prevent the adhesion of new surfaces of caoutchouc to each other or to other substances.

Cold has a remarkable effect on caoutchouc, rendering it rigid and inelastic, and this circumstance considerably detracts from the value of unvulcanized India-rubber. Here is a strip of India-rubber; you see that it is quite soft and pliable. I will now expose it for a few minutes to a temperature of 0° Centigrade, or the freezing point of water. It becomes, as you see, rigid and stiff, but its original pliability may be restored, either by warming or by applying sufficient tensile strain to it, to extend it to three or four times its length. One-half of this strip I will warm in water, heated to 50° Centigrade, and the other I will stretch. In each case you see that the caoutchouc is restored to its original condition. In the case of the stretching it is very likely that the effect is due to heat evolved during that operation. It is easy to illustrate the fact that heat is produced when India-rubber is subjected to tension. Here are some strips of India rubber, arranged side by side on a board. I bring them in contact with the bulb of an air thermometer, and you see that there is no indication of either heat or cold. The strips of India-rubber being now stretched to four or five times their previous length, the air thermometer indicates a considerable rise of temperature. Here is a similar set of strips, which were stretched some hours ago, and which, on trial by the air thermometer, we now find to have cooled down to the temperature of the surrounding objects. Note the effect of releasing the tension, and allowing the rubber strips to contract. You see that they have become so cold as to influence the air thermometer to a very considerable extent.

CONTRACTION OF RUBBER BY HEAT.

The effects of heat on India-rubber present many points of interest, and, in the first place, I wish to illustrate to you the effect of moderate heat on a stretched band of caoutchouc. Here is such a band, one end being attached to an index, pointing, at the present time, to the zero of this paper scale. Notice the consequence of applying a gentle heat to the caoutchouc band—it contracts as regards its length, but expands in a transverse direction, causing the index to move rapidly through a space of several degrees. This property, which stretched caoutchouc possesses, of contracting by heat, may be described by saying that, within certain limits, the tensile elasticity of caoutchouc is increased by an elevation of temperature. Caoutchouc, however, if heated to 100° Centigrade softens considerably, and almost entirely loses its elasticity, as you will perceive by examining this sample, which has been heated for some hours; while a heat of 120° Centigrade produces a most decided softening effect on caoutchouc of the best quality, but after exposure to this temperature, it recovers its pristine state by exposure to cold for a moderate period. If, however, the action of heat has been pushed still further, say to 200° Centigrade, the caoutchouc becomes converted into a permanently viscous body, which has little or no tendency to harden again. This viscous substance possesses the same composition as unaltered caoutchouc, and is of value as a medium for making air-tight joints, which can be easily undone. This glass jar has its top edge ground level, and, after applying a little of the heated caoutchouc to the ground edge, the jar may, as you see, be hermetically closed by a disk of plate glass. A joint of this kind may be broken and remade with the utmost facility and rapidity. I pass the jar round and you can study the matter for yourselves.

When caoutchouc is subjected to a temperature somewhat above 200° Centigrade, it becomes converted into a variety of volatile hydrocarbons, which present many points of interest, and you will find a tolerably full account of them in the manuals of chemistry. In this retort, the dry distillation of caoutchouc is being carried on, and in time very nearly the whole of the India-rubber will be converted into the mixture of oily hydrocarbons, only an insignificant carbonaceous residue remaining in the retort. The mixture of volatile hydrocarbons, often referred to as caoutchoucin, forms a very good solvent for caoutchouc and certain resinous bodies.

OXIDATION OF RUBBER.

India-rubber is subject to two kinds of deterioration and decay. In one instance it tends to become soft and loses its elasticity, while in the other it becomes friable, yellowish, and resinous in its nature. Examples of each kind of deteriorated rubber are on the table, and you will notice that, in the case of this specimen, we have a well marked instance of both kinds of deterioration going on side by side. The last-mentioned kind of deterioration has been clearly and indubitably traced to an oxidation of the caoutchouc. This oxidation is tolerably rapid when the caoutchouc exists in a finely divided state, and when it is exposed to damp at the same time; but the alternate damping and drying of the caoutchouc tends more toward its rapid oxidation than does a continual state of dampness. The resinous matter resulting from the oxidation of caoutchouc has been carefully studied by Spiller, who found that a sample of felt, originally composed of cotton fibers and India-rubber, had become so far changed during six years as to contain no trace of caoutchouc; but in its place he found a resinous substance resembling shellac. This resinous body, of which a sample is before you, is easily soluble in alcohol, and also dissolves in benzole. Alkalies dissolve it readily, and acids precipitate it from the alkaline solution. It contains 27·3 per cent. of oxygen.

The conditions under which the softening of the India-rubber takes place are not so well understood, but there is some reason to believe that this is due to incipient oxidation.

Ozone oxidizes caoutchouc with extreme rapidity, as Warren pointed out in 1877, and I have arranged a simple experiment to illustrate this fact. Through the open end of this glass passes a slow stream of air which has been slightly ozonized; that is to say, a portion of its oxygen has been converted into ozone. When the stream of ozonized air is allowed to impinge on a surface of India-rubber, you see that the surface is instantly corroded and roughened. Again, note the effect of allowing the ozonized air to act on the surface of a distended caoutchouc balloon—you see that it bursts immediately. I should mention, by the bye, that in the case of these balloons, the caoutchouc is slightly vulcanized, but the action of ozone on vulcanized India-rubber is similar to its action on the unvulcanized material.

It is extremely probable that the rapid deterioration of caoutchouc, which is known to take place under conditions which are not perfectly understood, is frequently due to the corrosive and oxidizing action of ozone.

Ozone, or some agent nearly resembling it, is often produced when oil of turpentine is exposed to the air, and this circumstance may perhaps explain the destructive influence which oil of turpentine occasionally exercises on India-rubber.

The whole subject of the deterioration of caoutchouc is one of great interest from a practical point of view, but to enter into its discussion would consume the whole of the time allotted to the present course of lectures.

ACTION OF LIGHT ON RUBBER.

Exposure to sunlight often causes the destruction of India-rubber, either converting it into a soft and sticky substance, or into a hard body, less soluble in benzole than unaltered caoutchouc; and it is quite possible to obtain a photographic print by exposing a film of India-rubber under a negative, and then dissolving away those parts on which the light has not acted, by means of benzole. Here is such a photograph made by Mr. Woodbury. I now project it on the screen, so that you may all see it. It is generally a discreet thing to keep India-rubber where it will not be exposed to the prolonged action of a powerful light, although there are cases in which exposure to light is a useful aid to the process of vulcanization. India-rubber is, to a certain extent, porous and cellular in its texture, as may be seen by a microscopical examination of a thin section. Again, if a thin leaf of caoutchouc is boiled for a long time in water, it absorbs a considerable proportion of this liquid. You see that this piece of caoutchouc has become quite milky and translucent from the absorption of water, and it probably holds, at the present time, as much as 10 or 15 per cent. of water. The amount absorbed may, in some cases, rise as high as 25 per cent. In a similar manner alcohol is absorbed by India-rubber, but this fluid is absorbed more readily than in the case with water.

SOLVENTS OF RUBBER.

Now, we pass on to a more important matter, namely, the action of such liquids as benzole or coal naphtha on caoutchouc. Here are two cubes of Para rubber, each being three-eighths of an inch across the face. One of these I will preserve as a pattern, and the other I will suspend in a bottle containing benzole. The cube suspended in the benzole will immediately begin to swell, and will continue to do so until it has attained a bulk about one hundred times as large as its original size. During the time that the cube is swelling in the benzole a certain proportion of the caoutchouc will become dissolved out, and incorporate itself with the bulk of the solvent.* Now, as a matter of fact, every kind of natural India-rubber contains two distinct modifications of caoutchouc, one of which tends to swell up in such a liquid as benzole, while the other dissolves and forms a true solution. The first mentioned of these bodies may be referred to as the fibrous constituent of caoutchouc, while the second may be spoken of as the viscous constituent. The proportions in which these two bodies occur in raw rubber varies extremely; Para rubber, of good quality, containing only a small proportion of the viscous constituent, while African tongue, on the other hand, consists principally of the viscous modification of caoutchouc. The viscous constituent of caoutchouc is the agent principally concerned in the joining together of freshly cut edges of India-rubber; and as we proceed with the study of caoutchouc, we shall see that, under certain conditions, the fibrous caoutchouc can be more or less perfectly changed into the viscous form. The treatment of the juice of the India-rubber trees is often of such a nature as to greatly deteriorate the caoutchouc obtained; a considerable proportion being thus changed from the fibrous to the viscous condition. This kind of injury to the caoutchouc can be obviated by coagulating the milky juice, and carefully drying the clot after it has been subjected to pressure. For experimental purposes, alcohol may be employed as a coagulating agent; while, on an industrial scale, alum has been tried with apparently an excellent result. The milk is strained to remove solid impurities, after which a small proportion of alum solution is added. The clot which separates is next drained or pressed, after which it is dried.

Caoutchouc dissolves more or less perfectly, according to its condition in various liquids, among which may be mentioned the various fixed and hydrocarbon oils, chloroform, ether, and carbon disulphide. Unless, however, the caoutchouc has been masticated or otherwise degenerated, it is doubtful whether a true solution is obtained.

THE BEST SOLVENT FOR RUBBER.

When a clear limpid solution is required, one of the best solvents is that proposed by Payen, namely, carbon-disulphide mixed with 5 per cent. of absolute alcohol. If one part of masticated caoutchouc is dissolved in thirty parts of the above solvent, a solution is obtained which can be filtered through paper, and may be employed in covering the most delicate moulds with successive layers of caoutchouc.

Caoutchouc may be utterly ruined by the use of impure solvents, and those experimenting with India-rubber solutions should, in cases where it is desirable to regenerate the caoutchouc by allowing the solvent to evaporate, take the utmost care not to employ any solvents which contain fatty or greasy matter.

Weak or diluted acids have little or no action on caoutchouc in the majority of cases, but strong sulphuric acid slowly acts on it, the action becoming rapid if heat be applied. Strong nitric acid acts on it with some energy, causing its entire destruction, and in a similar manner it is destroyed by the prolonged action of chlorine, bromine, or iodine; although these reagents, when their action is kept under control, have a vulcanizing or strengthening action, which will be referred to later on.

Regarding the action of sulphur on caoutchouc, much is to be said, but not at present. Alkaline solutions have little or no action on caoutchouc.

LECTURE II.

PURIFICATION OF RAW RUBBER.

The first step in the industrial purification of the raw caoutchouc consists in boiling the crude material in water for some hours; and during this process the caoutchouc becomes so far softened that it can be easily cut into slices by means of a knife. In actual practice, large covered rectangular tanks are employed, steam being injected in order to keep the water at a boiling temperature. The operation is imitated, for the purpose of illustration, by the arrangement you now see on the table. The water in this glass vessel having been kept boiling by means of steam during the last two hours, these lumps of raw caoutchouc are tolerably well softened; and you will notice that the India-rubber has become whitish from the absorption of water. This particular lump has most likely absorbed as much as fifteen or sixteen per cent. of water. The softened lumps are next cut up into thickish slices by a long sharp knife, and during this operation the workman throws aside any stones or large particles of foreign matter which he may meet. A pair of rather large even-speeded rollers are next brought into requisition to crush the slices of softened rubber. These rollers work in the same horizontal plane, or nearly so, and are fluted on the face by a series of deep spiral grooves, diamond-shaped projections being left between these. During the operation of crushing the India-rubber, a stream of water is kept running on it, this water being generally hot in the case of the first crushing operation. The first pair of rollers reduces the caoutchouc into the form

* At the close of the final lecture the cube immersed in the benzole was examined and found to have swelled to one hundred and twenty-five times its original volume, and in swelling it very clearly displayed the laminated texture of the rubber bottle from which it was cut.

Fig. 3.—COLLECTION OF THE JUICE OF THE INDIA-RUBBER TREE IN PARA.

of a very rough and broken-surfaced sheet, from which many of the mechanical impurities have been removed by the crushing action of the rollers and the rinsing action of the water. The very rough sheet produced, as above described, and of which a sample is before you, is again washed by means of a somewhat similar but smaller pair of rollers, cut on the face with a much finer diamond-shaped pattern, and this washing is continued until all mechanical impurities are worked and washed out of the rubber. Here are some samples of "washed sheet," and you will notice the peculiar broken surface which it presents, while by looking at it in certain lights, you will be able to trace out the diagonal pattern imprinted by the rollers. The engraving which I now project on the screen will give you some notion of the operation of washing India-rubber on a large scale, and I will now show you a diagram illustrating the manner in which the surface of a washing roller is cut. (See engravings to be given in next SUPPLEMENT.) The cuts are made from one-fourth to one-twentieth of an inch apart, according to circumstances.

The next thing is to illustrate practically to you the operation of washing. Here is a pair of fluted rollers, and on passing some of the slices of softened rubber through them a few times, you see that the impurities are washed away by the stream of water flowing from above, and the rubber is agglomerated into a kind of rough, irregular sheet, which I will pass around for your inspection.

The completeness with which solid impurities are removed from caoutchouc by the operation of washing is, at first sight, surprising; but it must be remembered, that as soon as the tearing action of the rollers enables water to penetrate between any foreign body and the India-rubber, this body is in a fair way to be carried off by the stream of water. The rubber, as it leaves the washing rollers, contains a considerable amount of water locked up in its pores, and in order to remove this, the washed sheet is taken to a stove or drying room, where it is hung up until all moisture has evaporated. A considerable loss occurs during the operation of converting the crude India-rubber into washed sheet, this loss occasionally amounting to over one-third of the original weight of the material; and the following table, which is extracted from a series of excellent articles on India-rubber and gutta percha, which have recently appeared in the *Universal Engineer*, will give some notion as to the average loss which various qualities of caoutchouc are subject to:

QUALITY OF CAOUTCHOUC.

	Loss by Washing.
Para	15 per cent
Negrohead	25 "
Guayaquil	40 "
Borneo	25 "
Ceara	28 "
African ball	25 "
African nigers	25 "
Madagascar	25 "
African tongue	35 "

MASTICATION OF RUBBER.

The washed sheets of India-rubber, considered as sheets, are of no practial utility, for they are irregular and full of perforations, but the washed sheet rubber is the starting point as regards most of the further developments of the rubber industry. By the operation of mastication, the washed sheets are worked up into compact homogeneous masses. The masticating machine, invented by Thomas Hancock, consists of an internal cylinder of metal, which revolves in a cylindrical iron casing. The India-rubber to be masticated, being placed between the rotating cylinder and the outer casing, becomes subjected to a very powerful mixing and grinding action, which ultimately reduces the India-rubber to a long solid lump, something like a sausage. Here is a model intended to illustrate the action of the masticating machine; and, if I introduce a little washed sheet India-rubber, previously softened by a gentle warmth, and get Mr. Barker to turn the handle, you will soon see that it is reduced to a compact form by the continual rolling and kneading action of the machine.

The masticating machines employed in actual practice are large and heavy, being often capable of working as much as two hundred pounds of caoutchouc at a time.

During the progress of the operation of mastication, which may last from four to five hours, the sausage-like block is occasionally cut in half, and the pieces are replaced in the machine in a reversed direction. Here is a piece of one of the masticated blocks, and if you examine this section of it you will see how very uniform the texture of the material has been rendered by the operation of mastication. The masticated rubber is generally converted into rectangular blocks by being forced into iron boxes, it being previously softened by subjection to the heat of steam at a moderate pressure. When thoroughly cold and set, the blocks are removed from the iron moulds. The rectangular blocks thus obtained are largely employed for the manufacture of the "fine-cut sheets," which sheets are extensively used in the fabrication of various small articles of caoutchouc. In order to cut these blocks into sheets, the block to be operated upon is fitted into a box attached to a sliding arrangement, like the bed of a planing machine. As the block is led forward by the mechanism, a slice is taken off by a sharp knife, which moves to and fro at the rate of two thousand movements per minute, this knife being kept wet by means of a stream of water. The outer sheet having been cut off, the block is raised in its box to an extent corresponding to the required thickness, and the operation of cutting is then again performed; the raising and cutting being now repeated until the whole of the block has been divided into sheets. The feed of the block up to the knife is generally at the rate of about one inch for each sixty cut, as one may perceive by counting the ribs on an ordinary piece of cut-sheet rubber. Occasionally, sheets are cut from cylindrical blocks, the blocks being made to revolve slowly on a kind of lathe, while a rapidly moving knife, attached to a rest, cuts the cylinder into one continuous sheet; but the method in question does not appear to find much favor in this country.

On the table you will find a very complete collection of specimens illustrative of the processes I have alluded to, these having been kindly lent by the Silvertown Company, Mr. Bell, Messrs. Tuck & Co., Messrs. Anderson, Abbott & Anderson, and others. In the case of these colored cut sheets, pigments are incorporated with the caoutchouc. The pigments are best incorporated by means of the mixing rollers, which will be described in the next lecture, the colored rubbers being then masticated; but the masticating machines may be used for the incorporation of solid matters with the caoutchouc.

During mastication the India-rubber undergoes a remarkable deterioration or degeneration, especially as regards its fibrous or insoluble constituent.

India-rubber during a thorough mastication loses much of its elasticity and strength, and either dissolves perfectly in cold naphtha or forms something which is remarkably like a true solution. To illustrate the difference in this respect between unmasticated rubber and that which has been masticated, I will put a slice of raw Para rubber and a similar slice of masticated Para rubber side by side in a bottle of

Fig. 4.—DRYING THE INDIA-RUBBER JUICE.

coal naphtha. The former will swell but retain its form, while the latter will dissolve in the course of a few days.* This kind of deterioration, due to mastication, renders the rubber eminently fit for the manufacture of the solutions or pastes employed in making waterproof textures, or for other purposes; and the superior qualities of masticated rubber for the preparation of solution were fully recognized by Hancock when the rubber industry was in its infancy. Although mastication alters the fibrous, or insoluble constituent, in such a way as to make it approximate in its nature to the soft or viscous constituent, there is always a notable distinction between the properties of a high quality of rubber, altered by prolonged mastication, and a low class rubber, such as African tongue.

Threads for elastic webbing were formerly cut from blocks of unvulcanized rubber; or even from the raw Para caoutchouc itself, this latter course being adopted in order to avoid the deterioration due to working or mastication. In the present day, however, vulcanized India-rubber is almost exclusively employed for the manufacture of threads intended for use in making elastic webbing. Notwithstanding this, what little I have to say regarding the cutting of threads I will say now, as the manipulatory details are not affected by the vulcanization or non-vulcanization of the rubber. Much ingenuity and skill has been expended on machines for cutting India-rubber into threads, and several systems have been employed. Sometimes, for example, a tube is converted into a single length of thread by one spiral cut; and in other cases a long sheet or strip is divided into a number of threads by means of a set of revolving knives. Here is such a set of knives, and I will first illustrate their action to you by cutting up a strip of sheet rubber, and then I will hand round the set of knives for your inspection. The sheets from which threads are cut are usually spread sheets, the nature of which will be explained in a future lecture, although calendered or rolled sheets are sometimes employed. The excess of the sulphur employed in vulcanizing the rubber is generally removed by boiling the threads in a six and a half per cent. solution of caustic soda, for a period varying from a quarter of an hour to one hour.

On the table you will find a selection of threads and of webbing manufactured from them, some of these threads being so fine that eight thousand yards only weigh one pound.

India-rubber threads have some industrial uses of interest, apart from their employment in the manufacture of elastic webbing. They are, for example, employed instead of weights in the Jacquard loom, as many as three thousand being occasionally used in one of these marvelous pieces of mechanism.

Here is a pretty little toy, depending for its action on a wound up spring formed of a thread of caoutchouc. When released, this spring actuates two vanes, arranged like the blades of a screw propeller, and away the thing flies, right over your heads, and it continues to fly about until the force stored up in the spring becomes exhausted. Perhaps we may here have the germ of a flying machine.

Later on in the course I shall have occasion to refer to the production of India-rubber threads by the process of squirting, this mode of procedure consisting of the forcing of softened caoutchouc through a die or hole.

A very large number of small articles, such as surgical goods, tobacco pouches, tubes, etc., are manufactured from the cut sheet rubber, and on the table you will find a considerable assortment of such articles, which have been lent by the firms previously mentioned.

The manufacture of such articles of cut sheet can best be illustrated, for lecture purposes, by a demonstration of the process of making the air balloons which are such favorite toys with children, and which are also extensively employed, especially in Paris, for advertising purposes. Mr. Dugwell, of New Road East, has kindly brought me a very extensive selection of these balloons and of the appliances used in their manufacture, while Messrs. Anderson, Abbott & Anderson, of Queen Victoria Street, have provided me with some India-rubber balloons of an unusually large size.

HOW RUBBER TOY BALLOONS ARE MADE.

Here, then, are some pieces of cut sheet rubber, and I will rub some French chalk on one side of each sheet. The next step is to arrange the sheets in pairs, the chalked surfaces being placed together in each case. In the next place, the outer surfaces of each pair are moistened with water, and the pairs are piled up together like the sheets of a quire of paper—eight pairs being superimposed in the present case. Here, then, is a steel punch, capable of cutting out a pear-shaped piece, corresponding to the uninflated balloon, and you see that I now punch pieces out of the pile of sheets. The moistened surfaces readily separate from each other, and the result is a number of pear-shaped pieces of rubber, each of these being formed of two sheets, French chalked over the surfaces, which are in contact, and slightly adherent round the newly cut edges. In the next place the sheets are separated at the part corresponding to the neck of the balloon. At this stage the uninflated air ball may be considered to have had its first form given to it, but the newly cut edges are very imperfectly adherent, only the extreme and inner angles of these being in contact, the major portion of the newly cut surfaces being exposed to view round the edges of the punched out pieces. A rather thin solution of India-rubber in benzole is now painted around these raw edges in order to make them more adhesive, after which the centers of each of the two pieces of sheet rubber composing the balloon are pulled out by the finger and thumb of either hand. This operation brings the adhesive edges of the balloon into perfect contact; they adhere, and the balloon is finished as far as construction is concerned. It is, however, usual to slightly vulcanize articles which have been manufactured from the cut sheet rubber, in order not only to give them increased elasticity and strength, but also to protect them against the influence of cold, heat, grease, etc.

Several methods of vulcanization are available for this purpose, and these will be discussed in the next lecture, but for the present I will just show you how the balloons can be vulcanized by a momentary immersion in bisulphide of carbon containing a very small proportion of protochloride of sulphur, one-fourth of a per cent. being sufficient for this purpose; although two and a half per cent. is a usual proportion for general work. The above is the well known cold-curing process obtained by Parkes. After dipping, the balloons are dried by a gentle heat on a tray covered with French chalk. They are now ready for inflation, and you see that Mr. Dugwell is busily engaged in the operation of inflating a number of those balloons which he has brought with him, and he intends to give each one of you an opportunity of taking away one of them.

The manufacture of other articles out of unvulcanized cut sheet is so analogous to the making of the air balls that I need not specially illustrate the processes; but I may mention that, although these articles are generally vulcanized by the cold process after they are made, the vulcanizing action is principally confined to the surface, so that these partially vulcanized articles are more or less liable to become rigid by the action of cold.

RUBBER CEMENTS.

Solutions of India-rubber have very many important uses, and they may vary in consistency from stiff pastes to limpid fluids, according to the proportion of rubber, its condition, and the nature of the solvent employed. A pasty solution or dough, containing about 20 per cent. of masticated rubber, dissolved in or incorporated with benzole or coal naphtha, is used in the industrial arts for a variety of purposes. It is employed extensively as a cementing material, and answers very well as a mounting medium for photographs, or for the repair of certain articles of India-rubber, while a textile fabric can be rapidly and easily rendered waterproof by being imbued with this substance. Such a paste or solution is usually prepared by allowing the rubber to swell in the benzole or solvent, and then kneading the product by means of a suitable machine. A very excellent apparatus for this purpose is the kneading and mixing machine invented by Mr. Pfleiderer.

RUBBER GLOVES.

By the evaporation of a solution of India-rubber in such a solvent as carbon disulphide or chloroform, a very delicate and pure film of caoutchouc may be obtained; and here is such a sheet of rubber, prepared by allowing the solution to dry on a leveled glass plate. Mr. Forster, of Messrs. Cow & Co., has utilized this principle in the production of India-rubber gloves, of extreme tenuity and uniformity of thickness. These gloves are formed by repeatedly dipping a kind of last, or mould, into a solution of rubber, and vulcanizing the film left on drying, by means of the cold process. By repeated operations, any required thickness of rubber can be built up. These gloves, some pairs of which I will hand round for inspection, are so thin that a surgeon may wear them while performing an operation, in order to protect himself from possible blood poisoning; or a photographer may employ them to prevent the staining of his hands by the salts of silver which he employs.

Unvulcanized caoutchouc is employed in the fabrication of the valuable cement known as marine glue, this being made by melting together one part of India-rubber, previously softened by or dissolved in coal naphtha and two parts of shellac.

* At the following lecture the bottle was shown. The raw rubber was intact, while the masticated sample had dissolved, with the exception of some traces of flocculent matter.

PIASSAVA FIBER.

Piassava fiber (better known as bass) is found, writes Mr. W. Wigfall in the *Journal of Applied Science*, abundantly in South America, and is the fiber of some species of trees known as the "rope-bearing palm" of the Brazils, and hitherto chiefly obtained from the province of St. Salvador (Bahia). The fruit it bears is the brown coquilla nut used by turners. In the wet or rainy season the natives ascend these palms and strip the trunks and branches of their fibrous foliage. Snakes and other venomous reptiles often lurk in this flossy substance, and but for the gain it brings the natives it would be difficult to induce them to venture up among it. The branches being thus stripped, the fiber is thrown down to the ground, and then in a very primitive way the native proceeds to comb or hackle it through stakes or sticks driven firmly into the earth, thus drawing out the long and stronger fibers, and leaving the finer flossy substances behind their wooden hackle. This tow they prize for making into ropes, etc., and the coarse or strong fibers (which run from 9 to 10 feet) they double in at each end to about 4 feet, and make up into rude bundles of about 14 lb. weight, which (when they have secured enough of) they place on a sort of raft, and float it down the rivers a distance of 150 or 200 miles to the nearest sea-coast towns, some of which are Uná, R. Ilhéas, Point Segura, Santa Cruz, and others, and they sell or barter it away for food, chiefly "manioca," with a class of traders known as "manioca merchants," who give the poor natives a very low rate of exchange for their far-brought produce. Manioca is a root not much unlike our English dahlia, which, when dry, is rubbed or ground down into a sort of coarse flour. The natives exchange their bundled piassava for this article of food.

These "manioca men" call themselves the "collectors and packers" of piassava in pressed bales for England, and latterly they have thought it expedient, by way of enhancing their profits, to introduce inside these bales (which they make up at from 1 cwt. to 2 cwt. each) large pieces of stone, old metal, mortar, sand, and huge logs of wood; in fact, anything to help the weight, and so adroitly do they manage this, that it is only when these bales are reopened that their nefarious practices are found out. These packers bring their pressed bales to market in native craft or on small steamers plying along the coast down to the port of Bahia. There the bales are accepted by the merchants, and shipped to Liverpool and London for broom-making purposes; but to such an extent has this practice of introducing *débris* into the bales reached, that recently an influential meeting of piassava merchants and manufacturers was held in London, when it was resolved that communications should be at once entered into with the government and merchants of Bahia requesting them to have all these pressed bales reopened and examined before shipment to England, with a view of putting a stop to this imposition. The exports of this article last year from South America are said to have reached about £100,000 in value, and the local duty paid to the Brazilian Government is about 21 per cent.

The first introduction of Bahia piassava was some thirty-eight or forty years ago, when it came over merely as dunnage (packing) with cargoes of sugar in South American vessels trading between that country and Liverpool. This dunnage was mostly thrown away, as was also native piassava rope, as useless after a vessel had discharged cargo.

A Liverpool brushmaker, seeing a lot of this apparently waste fiber in the docks, thought that it would make a good substitute for the ling and birch twig besoms then in use, and taking home a lot, he set about straightening it by steaming, combing, etc., and on chopping up the old cast-away ropes into lengths he found that by boiling the fibers of which they were spun, they became straight and of wiry appearance, and so he applied them to broom-making for street purposes. It was not long, however, before the thing was taken up by others, and great improvements were made in dressing it.

At present large amounts of capital are embarked in the piassava trade, and it is computed that over 2,000 hands are employed in England alone in making street and stable brooms all the year round, besides employment afforded to large numbers in works where the fiber is merely prepared for the trade. The neighboring countries of Germany, Holland, and Belgium are steadily working into the piassava fiber trade as makers, while our colonies of Australia, New Zealand, and the Cape are England's best customers.

AN AFGHAN JAMPAN OR SEDAN CHAIR.

"This large military station," writes Brigade-Surgeon Frederick W. Moore from Murree, Punjab, to whom we are indebted for the sketch, "was enlivened a few days since by the arrival of the Mustafi Habiboola Khan. This

AN AFGHAN JAMPAN OR SEDAN CHAIR.

notorious Afghan councilor was the Wuzeer, or Prime Minister and Chancellor of the Exchequer, to the Ameers Shere Ali and Yakoob Khan. His long knowledge of and intercourse with the chieftains of the tribes of Afghanistan would have made him a valuable acquisition to either side during the war. With his natural astuteness, seeing that the Afghan cause was lost, he came over to the British, and he was at once chosen as the most powerful and able mediator between us and the Afghan tribes. The political authorities on various occasions gave him large sums of money to smooth the way with these turbulent chiefs, more especially when he was negotiating with Mahomed Jan. The Mustafi was unsuccessful in bringing him to terms, though he did influence on our behalf some of the petty chieftains, and for a time seemed quite a zealous partisan. Ultimately, however, the innate Afghan treachery got the better of him, and, while under the garb of friendship he was taking our money, he was intriguing with Mahomed Jan against us. He was suspected, however, before he had wrought much mischief, and at last letters were found passing between him and the enemy, and he was immediately arrested and sent to India as a prisoner. His advanced age—namely, sixty or seventy years—and his decrepit state, probably saved him from a worse fate. In the order which sent him to these hills it was said that he was sent for the benefit of his health, and that he was to be treated with consideration. His son, twenty-three years of age, was allowed to accompany him, along with a few Afghan servants. Captain Gaisford, of the Frontier Force, 4th N. I., was placed in immediate charge of him, together with two or three native policemen. He lives in a very good house, ironically named Friendship Hall, and goes out once a day, generally in the evening, in a *jampan*, a sedan chair carried by four coolies. His son and an attendant ride behind him, and a very large man walks in front armed with a long stick. The old gentleman is too decrepit to need a further guard, for in his condition, and in so crowded a place as Murree, he could not make across the hills and far away. He is allowed no money, is forbidden to write any letters or receive any, his food is daily sent down to him by the Commissioner, and he has no communication with any natives excepting those around him."—*London Graphic.*

Atomic Weight and Principal Properties of Glucinum.—The authors (L. F. Nilson and O. Pettersson) give for the atomic weight of glucinum (O = 7·98) 4·542 as the mean of four determinations, former experimentalists having made it from 4·6 to 4·9. If glucina is Gl_2O_3 the atomic weight of the metal will be 13·65, in which case the atomic heat becomes completely normal.

THE MECHANICAL LABOR OF ONE MAN.

MR. RUHLMANN, privy counselor of government, publishes in the *Hanov. Wchnblft.* a note, in which he speaks about the mechanical labor which can be produced by a man, in proportion to the nourishment taken by him, and from his remarks, which are based upon reliable facts, we quote the following:

According to exact weight the Prussian infantry soldier has to carry the following:

1. Upon his body.....	12·208 lb.	avoirdupois.
2. Knapsack and contents..	17·894 "	"
3. Other weight.....	33·959 "	"
Sum total.....	64·061 "	"

If we now add to this the weight of the man himself as 154 lb., then the full weight which the infantry soldier in full war equipment has to transport is 218 lb., for which we can take the round sum 220 lb. According to the army regulations the length of the step of the infantry is thirty-two inches, and because that in marching a hundred steps have to be made in a minute, the velocity of the progressing motion is 52·36 inches in a second.

In order to find from these values the quantity of manual labor produced by a man, Mr. Rühlmann has employed the following formula, found by Mr. Poisson for the walking labor of man,

$$L = W(c+h)$$

in which c indicates the length by which the height of the center of gravity is increased, and which corresponds to the horizontal velocity of the progressing movement.

If we suppose that the height of the hips of the man is 37·40 inches, then c is equal to 2·75 inches, and h is equal to 3·54 inches; therefore the mechanical labor which the soldier has to produce at each step is:

$$220{\cdot}7\,(3{\cdot}15+3{\cdot}54) = 220{\cdot}7\times 6{\cdot}69 = 220{\cdot}7 \text{ lb.}\times 6{\cdot}69 \text{ inches} = 1478{\cdot}8 \text{ inch-lb.} = 123 \text{ foot lb.}$$

According to the regulation step above mentioned, the infantry soldier has to produce 208 foot lb. per second of mechanical labor (*i. e.*, about ⅜ horse power, while the usual labor of a workman is valued at only from 72·3 to 86·76 foot lb., or about ¼ horse power). This labor per hour would be 748,800 foot lb.; during a march lasting three hours 2,246,400 foot lb., and during an uninterrupted march of four hours 2,985,200 foot lb.

A man working at a winch produces (according to Christian) 2,534,400 foot lb. (daily labor).

A man ascending a mountain (according to Dupin Saussure), 2,361,600 foot lb.

Ascending stairs (according to Navier), 2,021,760 foot lb.

" " (according to Coulomb), 1,693,440 foot lb.

From this may be seen what great amount of mechanical labor is required of the Prussian infantry soldier during war, especially if we remember that the above given numbers are meant only for a plain and even street, and that heat, dust, odors, and other disagreeable things are not brought into consideration.

If we now want to find out at what cost the labor of a man is produced, we have to ascertain how much nourishment is absolutely necessary as an equivalent for this labor.

A healthy man of average strength transforms, within twenty-four hours, 0·554 lb. of carbon into carbonic acid, and at the same time 0·034 lb. hydrogen into water.

Now we know that by the combustion of 1 lb. of carbon 3672·7 calories, and by the combustion of 1 lb. hydrogen 15664·5 calories are developed. The whole quantity of combustion heat, therefore, is:

$$0{\cdot}554\times 3672{\cdot}7 + 0{\cdot}034\times 15664{\cdot}5 = 2567 \text{ calories.}$$

One calorie is equivalent to 3060 foot lb., therefore the heat used for nourishment by man is equal to $2567\times 3060 = 7{,}855{,}020$ foot lb. The greatest mechanical labor of man above mentioned, viz., that produced in ascending a mountain, corresponds to $\frac{2361600}{7855020} = 0{\cdot}30$, while the mechanical labor of the infantry soldier during a march lasting three hours is equal to $\frac{2246400}{78550100} = 0{\cdot}28$. If we take the medium between these two numbers, equal to 0·29, then we see that about 71 per cent. of heat are lost by perspiration, excrement, etc., and that only a small portion is utilized for mechanical labor.

It would take too much space to reproduce here the calculation by which Mr. Rühlmann found the quantity of nourishment which is necessary for the production of a certain amount of mechanical labor; we will only mention that, according to his opinion, a man for the labor of 2 21·760 foot lb. needs 2·5 lb. of bread and 0·73 lb. of meat per day. This is in harmony with the daily rations which a German soldier receives, consisting of 2·2 lb. of bread, 0·55 lb. of meat, 385·5 grains of salt, 231·45 grains of coffee, 4·2 ounces of rice, 5·2 ounces of barley, 10½ ounces of peas or beans, etc., and 4·4 lb. of potatoes.

MENTAL IMAGERY.

AN address was lately delivered by Mr. Francis Galton, F.R.S., at Swansea, in connection with the meeting of the British Association, on "Mental Imagery."

The author said: There is a true kinship between actual vision and the mental picture by which we recollect what we have seen. When light falls on the eye, a stimulus from without travels inwards toward the brain, where it associates itself with other waves of irritation proceeding from independent centers. In the formation of a mental picture the process is reversed. The action of the brain is propagated outward, becoming fainter as it travels. The same nervous chain is concerned in both cases, but its links are differently affected. We may define Shakespeare's phrase of seeing with the "mind's eye" as a condition in which activity of the nervous center bears a higher ratio to that of the nervous terminations than it does in ordinary vision.

The object of the lecturer was to point out the chief peculiarities in the mental imagery of different persons to show that they were natural and hereditary, and characteristic of different races, but that they admitted in a high degree of being developed by education, and to describe the most useful peculiarities for technical and artistic use as well as for philosophical generalizations. The medium characteristic of mental imagery among Englishmen was fairly vivid, but incomplete. The field of their mental view was narrow, but by removing the mental eye from point to point the whole of the image could be successively seen, so far as it was remembered at all. He based these conclusions on hundreds of replies sent to an elaborate series of questions, of the substantial truth of which he was assured by frequent cross-examinations. He found that the power of seeing an image vividly was by no means uncommon, so it was *a priori* reasonable to expect that education might develop the power of the large majority to that high level.

In actual proof of this he quoted the experiences of M. Lecoq de Boisbaudran (Enseignement Artistique, Morel et Cie., Paris), the late director of the Ecole Nationale de Dessein, in Paris, to show how well the visualizing faculty could be taught. His pupils were made to study simple models carefully and then to draw them from memory, and in a few months they had no difficulty in summoning the required images, in holding them steadily, and in drawing them. A commission of the Institute, appointed in 1852, to inquire into the results, reported most highly in their favor. M. Legros, the present Slade Professor of Fine Arts at University College, was one of M. Boisbaudran's pupils.

A description was given of many peculiarities of mental imagery, such as the strange and durable association in the minds of some persons with colors and letters, or with days of the week, and the curious tendency of about one person in every thirty to visualize numerals in definite forms, which the lecturer recently described at the Anthropological Institute. These are examples of a want of flexibility in mental imagery that is characteristic of those who can with difficulty see an object mentally in more than one or two aspects. There are, for instance, many who cannot recall the faces of dear relations who have died, though those of persons who are indifferent to them are easily recollected. This is chiefly owing to their seeing familiar faces very often in many aspects, and to the memories confusing one another. Philosophers who deal in abstract ideas avoid concrete representations and suppress mental imagery, and often lose the visualizing faculty by disuse. But those whose mental imagery can be educated so as not to be hard and persistent in its character, abandon a great deal of much value to them by the disuse of this power. They lose the only means they have of creating a mental generic picture under the conditions explained by the lecturer last year at the Royal Institution, and as illustrated by his plan of composite portraiture, of which he exhibited specimens.

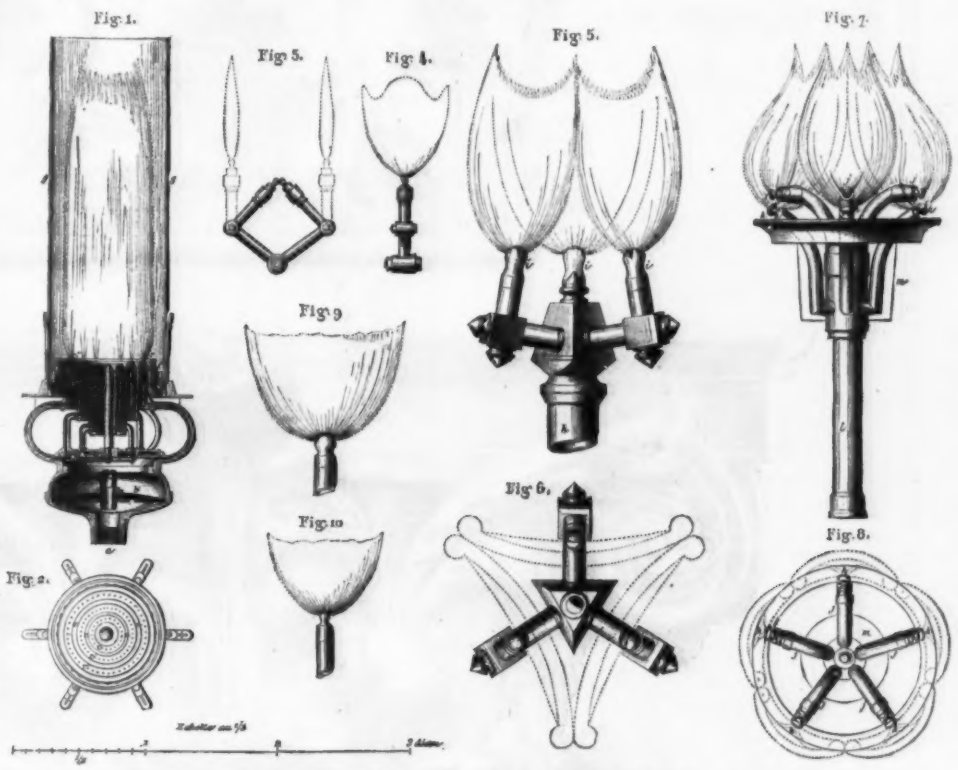
able in extent and accuracy to that of this barbarous Esquimau. The visualizing faculty was of importance in every trade and profession where design is required, because the workman ought to have a clear mental image of what he intends to do before he takes a tool in hand. The pleasure its use can afford is very great, many correspondents saying that the delight of recalling beautiful scenery and great works of art is the highest they know. A faculty that is of importance in all technical and artistic occupations, that gives accuracy to our perceptions and justness to our generalizations, is ignorantly starved by disuse instead of being cultivated in the way that will bring the best return.

IMPROVED GAS BURNERS.

SINCE the recent experiments with electric light have shown that probably some time will pass before this kind of light can be adapted for public use, several chemists have made an effort to improve the gas light by constructing burners which give to the flame a greater intensity. The most important improvements in this direction will be the subject of the following article.

Leaving aside some experiments made in Scotland, in regard to the illumination of light-houses by gas, the merit of the first labors for the construction of burners with an intense focus is due to Mr. Sugg, a renowned manufacturer of gas-burners in London, and although a long space of time has elapsed since Mr. Sugg made his inventions, they are of so important a nature as to deserve to be noticed in this place.

Mr. Sugg's apparatus has a burner which is provided with a double current of air, and is especially applicable for glass chimneys, being constructed after the fashion of lamps in light-houses, which have multiple wicks. It consists of three circular concentric rings, each of them emitting the gas through a series of holes in a jet of cylindrical form. The inner ring contains 24, the middle one 54, and the outer one 66 holes. The diameter of these openings varies from 0·05 inch to 0·07 inch. This diameter was found to be the most practical, after repeated experiments, which are



IMPROVEMENTS IN GAS BURNERS.

After giving details of various and not uncommon peculiarities, he stated as a not unattainable ideal by the majority that we should aim at the following result: The power of calling up at will a clear and complete image of any object we have studied, and to be able to see it from any desired aspect; to construct clear images from description, and to alter them as we please; to create generic images from several different but somewhat similar elements, and to carry away pictures at a glance, more complicated than we could analyze at the moment of seeing them.

The lecture was illustrated by specimens of the "visualized numerals," some simple, some shaded, and others colored. He showed the practical application of his method of "statistics by intercomparison" in obtaining median, quartile, octile, and sub-octile values for the vividness of mental imagery. He also exhibited specimens of aboriginal work by the bushmen of South Africa, from the fine collection of Mr. Stow, who has very lately sent some specimens to England, in hopes that means might be found for the publication of the whole of them. Also from Esquimau and their kinsmen, the ancient cave dwellers. All these testified, as he showed, to a race peculiarity of mental imagery, which was probably enough, as the tendency to visualize clearly was a natural gift, and he had found it to be hereditary in an exceptionally high degree. From among the many evidences of the power of the Esquimau to carry a mental image of a large extent of country, he exhibited a facsimile of an aboriginal map, one of many contained in Hall's "Journals," published last year by the United States Government. It was the chart of a complicated coast line, extending nearly 1,000 nautical miles in a direct line, over which the man had canoed during his life, and it was drawn from memory alone. It might be compared to a chart of the south coast of England, the whole of those of France and Spain, and of the opposite shore of Italy.

By the side of this was shown the Admiralty chart of 1874 of the same region, and the general coincidence between the two was striking. There was, to his knowledge, no instance among the many route maps compiled up to very recent years by travelers totally unprovided with instruments in Africa, Asia, and Australia, of any that were comparable to little noticed by our modern manufacturers of gas-burners. The gas enters into the combustion-rings through exterior tubes, which also serve as supports; annular spaces between these rings permit a free circulation of air. The gas-jet is surrounded by a glass cylinder, having a diameter of three and one-sixth inches, and a height of about twelve inches. Mr. Sugg has carefully avoided using solid brass supports for the cylinder, which give much shadow and detract about five per cent. of the light, and has instead ingeniously adopted the small slender tubes which emit the gas. The practical result corresponded to the ingenious composition of the apparatus; a splendid light was produced with comparatively little consumption of gas. In using 30 cubic feet per hour, the lamp gave a light having the intensity of eleven and a half Carcel lamps. Consequently, about 3¼ cubic feet would be the amount used per hour for one Carcel lamp; this is a great advantage, for generally it was supposed that about 4 cubic feet had to be used for that purpose.

Mr. Sugg's lamp had only one disadvantage, viz., that it was too delicate and too sensitive to currents of air, and could therefore only be used inside of buildings. The next improvement to be made was to construct a lamp which could be exposed without disadvantage to atmospheric influence, and at the same time would give an intense light.

In 1878 Mr. Coze, the director of the gas company at Rheims, published a pamphlet, in which he endeavored to give a solution of this problem. This improvement was based upon the following experience:

Two gas-burners, called candle-burners, are carried by a single support, and are so arranged upon two movable elbows that the direction of their flames can be regulated at will. Each burner uses about 2¼ cubic feet per hour, the total expenditure being 4½ cubic feet. If the two flames are burning parallel to each other, then their intensity is equal to one half of one of Carcel's lamps, while, if the flames are inclined toward each other so as to have the shape of a fan, then the intensity increases 100 per cent., being equal to one of Carcel's lamps.

Taking these facts for a basis, Mr. Coze has endeavored to increase the intensity of the gas-light by uniting several

burners so that their flames cross each other; and this idea has been continued by Mr. Mallet, the Nestor of the gas manufacturers.

Mr. Mallet's lamp consists of ten burners of the form usually called papillon (butterfly). He has, in a peculiar manner, united these "butterfly-burners," which are at present used for the street lamps everywhere in Europe, and which were devised by Dumas and Regnault, scientists, well known by their scientific labors. Five of the burners have a diameter of 0·3 inch, and a slit of 0·02 in width, while five smaller ones have only a diameter of 0·7 inch, and a slit of 0·01 in width. The large and small burners are coupled by twos, and the five flames which rise from the same plane, forming a regular pentagon, cross each other and give a very intense and steady light. By a very ingenious device half of the flames can be extinguished, and thus the expenditure of gas can be modified.

Mr. Mallet's lamp consumes 52 cubic feet per hour, and its light has an intensity of 15 Carcel lamps, which would be equal to an expenditure of 3½ cubic feet per hour for each Carcel lamp.

The latest improvement in the construction of burners was that made by M. Audouin, who, at the suggestion of M. Camus, a member of the gas company of Paris, invented a new gas lamp, which has very great advantages. This gentleman used "butterfly-burners" having a great diameter (about half an inch), and provided with a slit of a width of about one-third of an inch. These burners give, if burning alone, a flame which has about thrice the surface of the gas flames in our street lamps. In uniting upon one fork three of these large burners, and placing their flames so that they are convergent, M. Audouin has obtained a bunch of light which has a very great intensity, and a lamp which is superior to all previously invented. This lamp needs 37 cubic feet per hour, and is equal to 12 Carcel lamps, thus using for each Carcel unity only about 3¼ cubic feet. A careful investigation of these different apparatus shows that from a theoretical point of view, for the construction of gas lamps, "there is great economy in a large expenditure," and that it is more advantageous to use for the consumption of a certain quantity of gas a few well-constructed burners than to distribute this quantity to a great number of cheap and imperfect ones, for in the first case the intensity of the light is doubled, and even tripled.

CAPITALS OF PILASTERS, ITALIAN RENAISSANCE.—*From the Workshop.*

A Peculiar Alteration of Butcher's Meat.—The author (M. Poincare), in examining a series of meat condemned at the abattoir of Nancy, has detected heterogeneous elements, which appear to him to be parasites not yet classified, and which he has figured and described. He considers that they present a certain analogy with gregarines, and asks whether they may not be one of the phases or metamorphoses of the tænioids, and if it is not through their mediation that raw beef gives rise to tænia in human subjects.

GLASS MANUFACTURE.

The illustrations on page 3966 relative to recent improvements in this interesting branch of industry are in connection with an invention by Herr Siemens, of Dresden, for improving apparatus for manufacturing and moulding glass articles.

Glass melting tanks have hitherto been constructed under the belief that the fining operation of the material takes place mostly at the surface, and consequently such tanks have been made of considerable superficial area, but of very moderate depth, such as a foot or eighteen inches. In such tanks floating bridges or rings have been used, and these have been made shallow, so as only to exclude from the working out spaces parted off by them foreign matters floating on the surface. It has been observed, however, that in the glass melting process the metal as it fines sinks below the surface, and consequently in order to work out the metal to the best advantage, the depth of the tank should be very considerably increased, and the floating vessels or rings used should be of such form and construction as to take their supply from a considerable depth below the surface of the metal.

According, however, to the invention we now notice a continually working regenerative gas furnace is employed, in the tank of which there are boats or floating vessels, made of refractory material, one for each working out hole or door, constructed and operating as will be now described. Each boat is divided into three compartments;

the first supplied through holes at or near its bottom with glass taken at a level some distance below the surface of the material in the tank; the second compartment is separated from the first by a bridge or dam, over which the material flows from the first, this bridge acting as a trap to prevent back flow of the material, which undergoes fining in the second compartment. The third compartment, which in some cases may with advantage be covered by a hood from the direct action of the flame, receives the fined glass from the partition which separates the second from the third compartment. From the third compartment the glass is worked out. Each boat is made with horns projecting from the front of the third compartment, serving as fenders to keep the boat from contact with the side of the tank, to which it might otherwise adhere owing to the cooling of the material next the side of the tank.

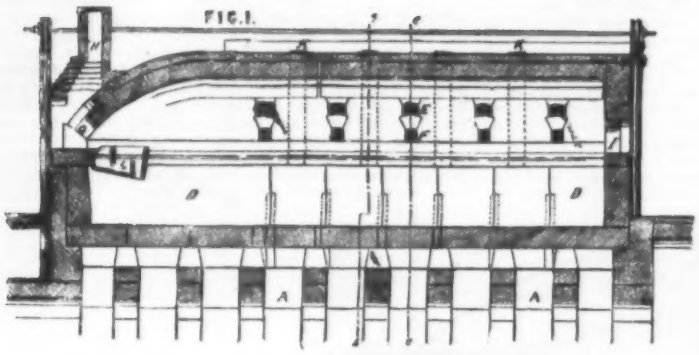
The boats instead of having three compartments may have a greater number; for example, the third compartment may supply a fourth over a dam or bridge acting as a trap to prevent back flow, and the fourth compartment thus supplied may supply from its bottom a fifth or working out compartment. These boats may also be employed in tanks other than those worked on the regenerative gas furnace principle, and they may be used in pots, worked as tanks, that is to say, with the hottest flame playing continuously on the surface of the material contained in them, in which case they can be loosely built round and supported by refractory material up to or nearly up to their upper edges.

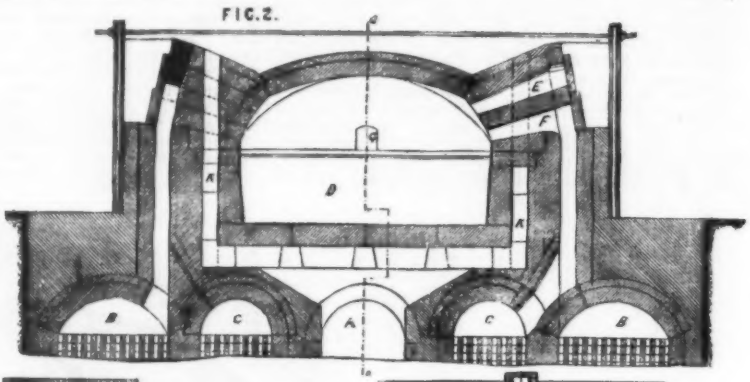
For moulding bottles or similar articles the moulds are constructed as follows: The bottom, the cylindrical body, and the folding portions which are opened and closed in the usual way are all made with openings through them, giving free passage for access of air to cool the mould and the glass, also for egress of the fumes or gases proceeding from the carbonaceous or oleaginous material usually introduced for lubricating the mould, so that the bottle or article blown in it can be freely turned round therein while it is being blown. These openings through the mould are narrow at the inside and widen out considerably toward the outside, so that they may readily clear themselves of any soot, ash, or other material entering them. In the upper part of the mould they may be in the form of vertical slits; in the vertical sides of it they may be in the form of slits cut obliquely, and in the bottom they may be in the form of segments separated by bars lying obliquely to the radii. When the article is turned round while it is being blown, the edges of the openings have a planing or a smoothing action on the surface of the glass. In some cases instead of turning the bottle or other article round in a stationary mould the latter is caused to turn round or partly round while the article blown in it is held stationary. Moulds with openings as above described are obviously applicable in such cases, their operation being the same whether they themselves or the articles in them are caused to rotate. In blowing bottles which have recesses in their bottoms the center of the bottom of the mould forms a pivot on which the bottle turns, and when the recess has a projecting nipple, a corresponding hollow is formed at the apex of the mould bottom, the nipple in that case forming the pivot on which the bottle turns.

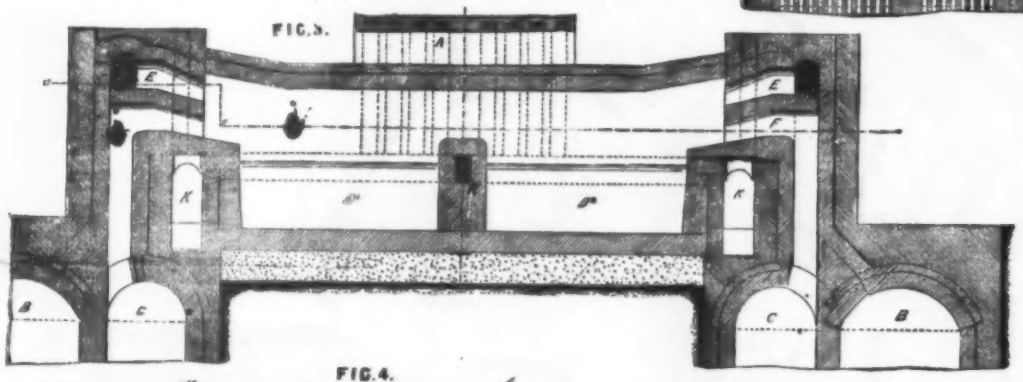
In the drawings which we present for reference, Fig. 1 is a longitudinal section on the line, *a a*, of Fig. 2, which represents two half transverse sections, the left half on the line, *b b*, and the right half on the line, *c c*, of Fig. 1, showing the construction and arrangement of a deep glass tank according to this invention. A is the cave with the regenerative chambers, B B, for air, and C C for gas arranged on each side of it below the tank, D, which is made to contain a considerable depth of glass for the purpose above stated; E and F are the flues conveying the heated air and gas up from the regenerative chambers on the one side, while the products of combustion pass down by corresponding flues to the regenerative chambers on the other side, this movement being from time to time alternated in the known manner according to which regenerative gas furnaces are operated. G is one of the working out holes, of which a number are arranged at one end of the tank, each having a flue, H, to cause a draught of air for the protection of the workman. I is one of the feeding doors, of which there may be several at the end opposite to that where the glass is worked out. The bottom and sides of the tank are exter-

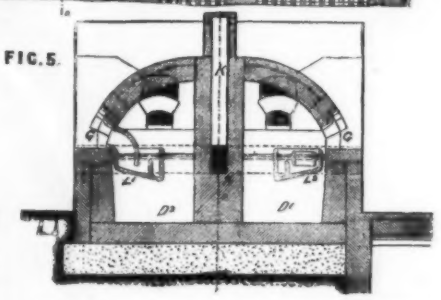
SUGGESTIONS IN DECORATIVE ART.—CARVED PANEL ORNAMENT, DESIGNED AND EXECUTED BY TH. SCHOOP, VIENNA.—*From the Workshop.*

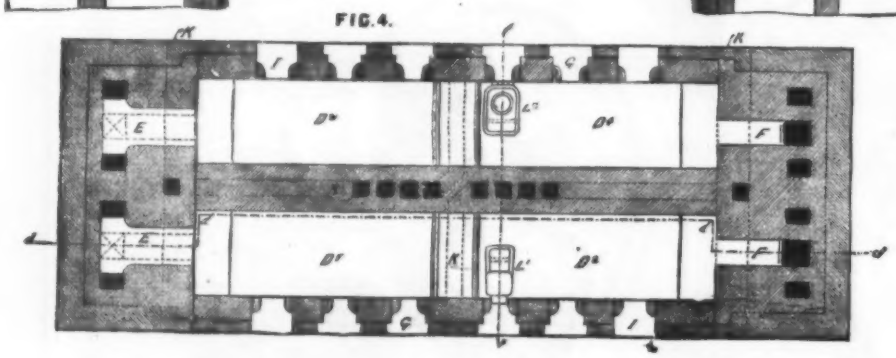
GLASS MANUFACTURE.

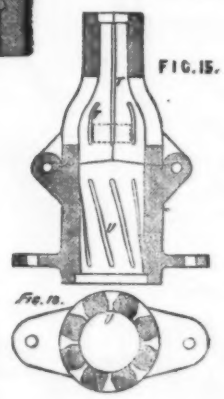


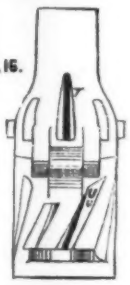


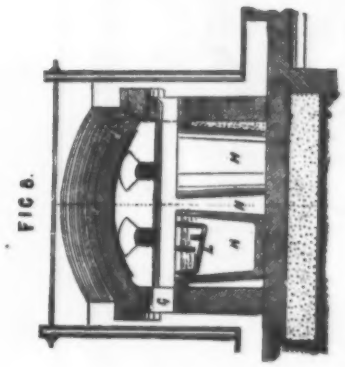


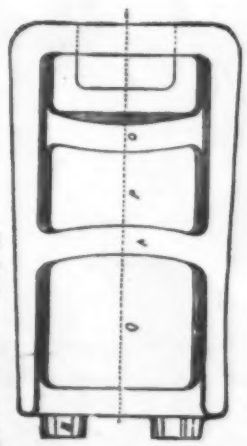


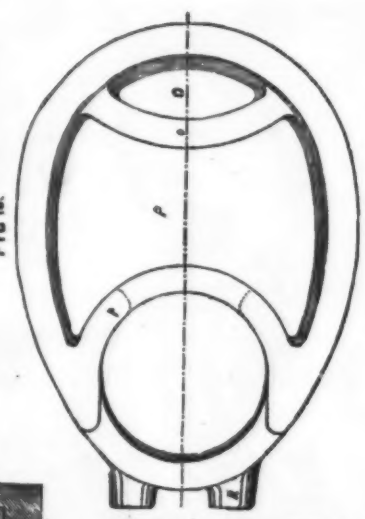


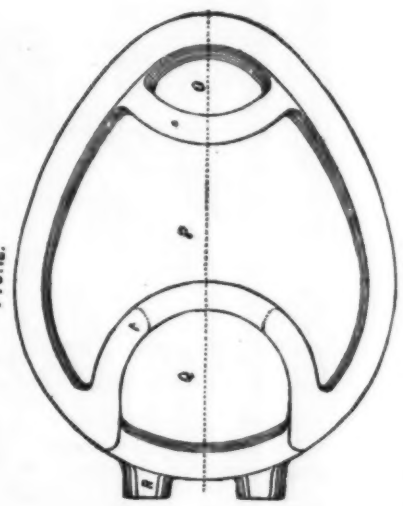


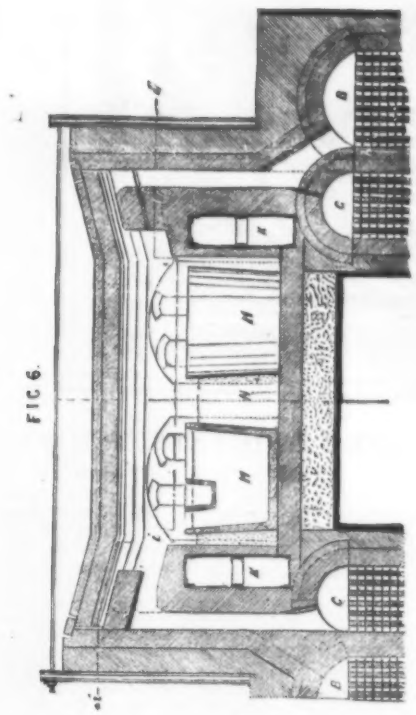


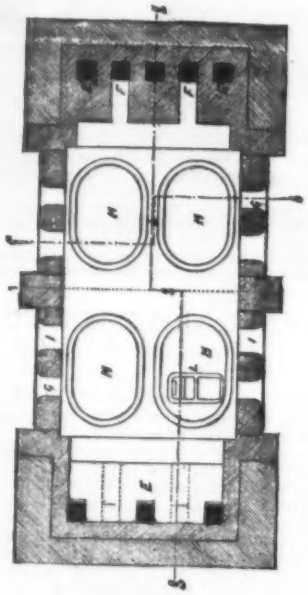


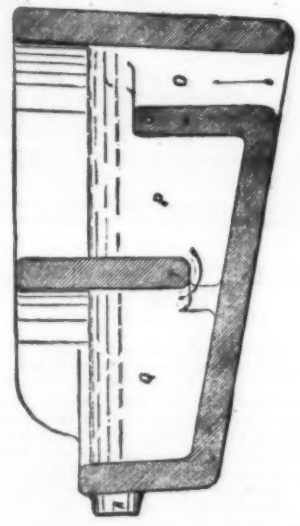


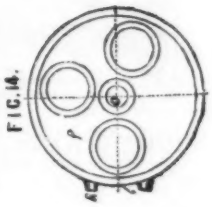












nally cooled by the air currents through and from the cave, A, and through flues, K. Fig. 3 is a longitudinal section of a deep glass tank furnace divided into compartments, this section being taken on the line, *d d*, of Fig. 4, which is a plan on the line, *e e*, of Fig. 3. A transverse section on *f f* (Fig 4), is shown at Fig. 5. The furnace is divided into four compartments forming four tanks separated by four partitions, which as well as the end bridges are kept cool by currents of air through flues, K. G are the working out holes at each side, each of which may have a boat, as shown at L^1 or L^2, or two or more such boats of smaller size of all kinds that will presently be described. The furnace may obviously be divided into a less or greater number of separate compartments according to the varieties of glass to be produced. Fig. 6 is a longitudinal section on the line *g g*, of Fig. 7, which is a plan on *i i* (Fig 6), of a pot furnace, Fig. 8 being a transverse section on *h h* (Fig. 7). This furnace contains pots, M, which are bedded in and supported by refractory material, N, so that they may be made of oval form or forms other than circular, the support given by the material in which they are bedded rendering great strength of the pots themselves unnecessary, and the bedding material protecting them from extreme heat or change of temperature. The parts of this furnace corresponding with parts of those previously described are marked by similar letters of reference. The number of pots may obviously be varied according to the dimensions and purpose of the furnace, and the pots may be worked continuously as tanks.

The boats of floating fining vessels according to this invention may be made of various forms, some of which are shown at L, L^1, L^2, in Figs, 1, 4, 5, 6, 7, and 8, and to an enlarged scale at Fig. 9, which is a longitudinal section, and Fig. 10 which is a plan, 11 and 12 being plans of modified forms. A circular form is shown in section at Fig. 13, and in plan at Fig. 14. O is the inlet by which the glass enters the boat. It flows over the bridge, *o*, into the fining compartment, P, and thence under the bridge, *p*, into the working out compartment, Q, which as shown at L^1, in Figs. 4 and 5, is sometimes provided with a hood. This compartment may be dispensed with when floating rings are employed, as shown at L^2, in Figs. 4 and 5, and in Figs. 13 and 14. When there are several such rings the glass may be worked out from them in succession.

Fig. 15 is a vertical section, and Fig. 16 a side elevation of a skeleton bottle mould according to this invention. Fig. 17 is a section showing the bottom piece forming the pivot on which the bottle is turned round while it is in the mould. Fig. 18 is a sectional plan of the body of the mould, and Fig. 19 is a plan of the bottom piece. The mould as shown in the drawings is made with slits or openings, T in its upper part, U in its body, and V in its bottom, permitting escape of fumes or gases, and admitting air to cool the glass, and prevent the mould from becoming overheated. The edges of the slits serve to plane or smooth the surface of the bottle when it is turned round in the mould, and in order that they may more efficiently exert this planing action their edges are set obliquely to the direction of motion of the surface on which they act.—*Universal Engineer.*

MANUFACTURE OF COTTON CORDS.

THIS invention, which is due to Mr. J. H. Openshaw, of Bury, Eng., deals with improvements in the manufacture of cloths known as cotton cords. These improvements consist of a peculiar method of weaving cotton cords, known as six shafts or eight shafts, having six ends of warp to each rib of cord. By this method a cloth is obtained with a firmer, stronger, and better "bound in" back than in the old double jean back cord; a more curly appearance (known in the trade as "cockle") is produced upon a cloth of less weight than is produced upon cloth woven by the old method.

A new means of combining the face with the back is also introduced. Moreover, in cloth woven in this manner, there is less risk of damaged and cut backs in the finishing of the cloth, on account of the inside of the back being almost like plain cloth, instead of being "twilled," as in the old cord. The "cockle" is formed by the perfect manner in which the weft threads are made to intersect the two warp threads which bind in the face.

By referring to the accompanying illustrations, it will be seen that Figs. 1 and 2 are patterns of six end cords with the new back, and with the old order or succession of face picks, while Figs. C, D, E, and F, and Figs. 3 and 4 are patterns of six end cords, with the new back allied to the new method of combining the face and back together.

Figs. 5 and 6 are patterns of eight end cords woven by the improved method. Figs. 7, 8, 9, and 10 are sectional diagrams of the new back applied to six and eight end cords. It will be seen in all the figures of 7, 8, 9, and 10, that each back pick intersects or divides the warp threads ten times to the "gait over," or "repeat" of the pattern.

In the diagrams showing the back picks the black dots represent the warp threads.

In Fig. 7 the first back pick misses intersection between the third and fourth and between the tenth and eleventh ends.

The second back pick misses intersection between the fourth and fifth and between the ninth and tenth ends.

The third back pick misses intersection between the fifth and sixth and between the eighth and ninth ends; and

The fourth back pick misses intersection between the second and third and between the eleventh and twelfth ends.

In Fig. 8 the first back pick misses intersection between the third and fourth and between the eleventh and twelfth ends.

The second back pick misses intersection between the fifth and sixth and between the ninth and tenth ends.

The third back pick misses intersection between the fifth and sixth and between the ninth and tenth ends; and

The fourth back pick misses intersection between the third and fourth and between the eleventh and twelfth ends.

In Fig. 9 the first back pick misses intersection between the third and fourth and fourth and fifth, the sixth and seventh, twelfth and thirteenth, the fourteenth, fifteenth, and sixteenth ends.

The second back pick misses intersection between the fourth and fifth, the sixth, seventh, and eighth, the eleventh, twelfth and thirteenth, and the fourteenth and fifteenth ends.

The third back pick is the reverse of the second back pick, and misses intersection at the same points.

And the fourth back pick is the reverse of the first back picks, and misses intersection at the same points.

In Fig. 10 the first back pick misses intersection between the third, fourth, and fifth, the sixth and seventh, and the twelfth, thirteenth, fourteenth, and fifteenth ends.

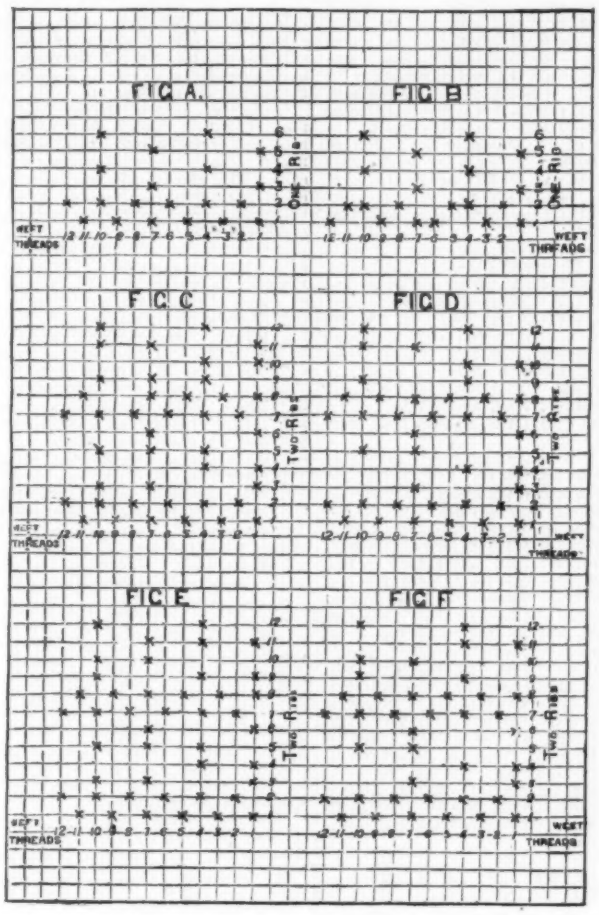
The second back pick misses intersection between the fourth, fifth, sixth, and seventh, the eleventh, twelfth, and thirteenth, and between the fourteenth and fifteenth ends.

The third back pick misses intersection between the fourth and fifth, the sixth, seventh, and eighth, the tenth and eleventh, the twelfth and thirteenth, and the fourteenth and fifteenth ends; and

The fourth back pick misses intersection between the second and third, the fourth and fifth, the sixth and seventh, the twelfth and thirteenth, and the fourteenth, fifteenth, and sixteenth ends.

By further reference to the illustrations, it will be seen that Fig. A is a tabby or plain back cord woven by the improved method; Fig. B is the same woven the old way. It is evident by comparing the two figures that the weft threads in weaving intersect more alternately in Fig. A the two warp threads marked 1 and 2 (or the warp threads that bind in the face) than the weft threads intersect the first and second warp threads in Fig. B. It is this perfect or alternate intersection which causes the shrinking or cockle on the cloth. As, however, a tabby or plain back cord has a comparatively inferior back to the old double jean back cord for "raising" or obtaining a woolly appearance upon it in the subsequent finishing, and also it being impossible to weave cloth above a certain weight by either Fig. A or Fig. B (say, for 34 in. width in the reed and 75 yards in length, not above 65 lb. in weight), Fig. C is employed for cloth of the same width and length as mentioned above, from 65 lb. to 75 lb. weight, and Fig. D for cloth above 75 lb. in weight.

Both Figs. C and D can be modified (see Figs. E and F). Upon examination and comparison of the figures, it will be at once seen that Figs. E and F are only variations or modifications of Figs. C and D, as in all four Figs. C, D, E, and F, the back is formed by the weft thread or pick intersecting the warp threads ten times in the full breadth of the figure or pattern.—*Universal Engineer.*



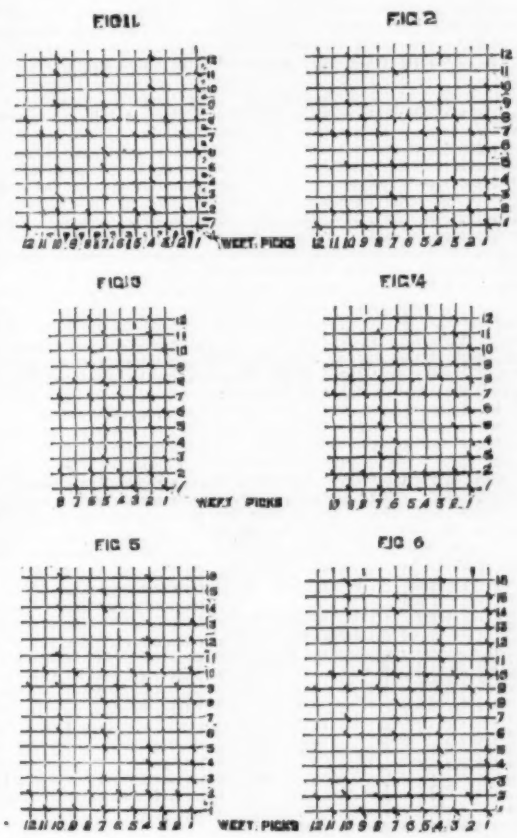


FIG 7

FIG 8

FIG 9

FIG. 10

PRINCIPLES INVOLVED IN DYEING.—Gustav Engel has experimented upon animal and vegetable substances to ascertain the principles involved in dyeing. All the experiments agreed in proving that the facility with which substances absorb and retain dyes depends almost entirely upon physical structure, and especially upon capillarity.

LIGHTNING CONDUCTORS.*

By Richard Anderson, F.C.S., F.G.S.

On the present occasion I wish to bring under the notice of the association a few cases of damage resulting to buildings which had lightning conductors attached, which have come under my own observation. The adducing of such cases furnishes the best argument, I imagine, not only for a record being kept of all accidents, but of a regular inspection of buildings which have lightning conductors attached to them.

On the 10th of October, 1878, a furniture repository situated at the back of Victoria Station, Westminster, was struck by lightning, although a conductor was attached to the building. The warehouse, which is built of brick, is 110 ft. by about 80 ft. wide, the roof is flat and covered with lead. At the southeast corner, a slate-covered tower with 4 ft. of iron cresting, rises to the height of 20 ft. above the roof. To this ornamental ironwork a solid copper band lightning conductor, ¾ in. broad by ⅛ in. thick, and weighing 0·43 lb. per foot, was attached. A terminal made of ⅝ in. diam. copper tube, with three discharging points 6 in. long, screwed into the rod 3 in. from the top, rose 3 ft. above the iron cresting. The rod was attached to the ironwork by means of copper wire, and the band to the slates and brickwork by gun metal clips. The copper was of very good quality, having a conductivity of 92 per cent. The electric discharge fell on the point of the lightning conductor, bending it, driving out two of the discharging points, and twisting the third. The iron cresting was shattered, and considerable damage done to the tower. Part of the discharge was no doubt carried off from the lead roof by the rain water pipes, which were in metallic communication with it. On testing the conductor shortly after the accident, I got no deflection of the galvanometer needle, and on opening out the earth terminal found the conductor carefully insulated in concrete.

On the 10th of June last, lightning struck the point of the conductor at St. Mark's Church, Skelton, slightly bending it, but did no further damage. The conductor was made of ⅝ in diam. copper rope, and had a conductivity of 52·50 per cent. On testing the conductor, while rain was falling, I found the resistance to be 600 ohms. The conductor was buried 9 in. among bricks, lime, etc., and carried 15 ft. from the building. On Saturday, the 26th of June, 1880, a heavy thunderstorm passed over South Lambeth, the lightning doing considerable damage to All Saints Church. The building in question, the style of which partakes of the characteristics of the thirteenth century, consists of a nave 92 ft. 6 in. long, 25 ft. wide, and 36 ft. high to the plate level of the roof, a chancel 31 ft. long, 20 ft. wide, and 48 ft. to the ridge, also north and south aisles 13 ft. 3 in. wide. A stone cross 4 ft. high stands on the apex of the west gable, and another of similar size stood 92 ft. 6 in. from it on the east end of the nave, a ridge of red tiles separating them. A ⅝ in. diam. copper rope conductor, consisting of 49 wires, was attached to the cross on the west gable, a 5 ft. point made of copper tube rising 18 in. above it. On the afternoon of the 10th, lightning was observed to strike the point of the conductor, then dart to the stone cross of the east end of the nave, throwing it down and injuring the roof of the north aisle. On testing the conductor a few days after the building was struck, I found the lightning rod had no "earth" whatever, the rope being simply stuck 2 in. in loose rubbish. The copper was very impure, the conductivity being only 32·10 per cent., or about double that of iron.

In July last, about half-past five in the morning, lightning struck one of the chimneys of Normanhurst Court, near Battle, Sussex, notwithstanding a lightning conductor was attached to it. Normanhurst stands on high land, and commands a magnificent view of the whole channel from the South Foreland to Beachy Head. The buildings are constructed of hard blue stone, roofed with Brosely tiles; and are in the style of the age of Francis I. There were two lightning conductors on the buildings; one on an octagonal tower, which rises from the S. W. angle, having a balcony and a lofty stone spire, about 120 ft. high, the other on the S. E. chimney, which was struck, about 126 ft. distant from the tower. The lightning conductors consisted of 12 copper wires, 15 B. W. G., woven into the form of a band 1 in. broad, and weighing 0·36 lb. per foot. The air terminal, which rose 3 ft. above the chimney coping, consisted of an iron point 12 in. long, covered with a composition which on scraping appeared to be lead; this was attached by means of a coupling joint to a copper tube 6 ft. long, and weighing 0·28 lb. per foot. The copper band was connected to the rod by another coupling joint. The chimney coping consisted of eight ornamental stone pinnacles 3 ft. high and 2 ft. square at the base. The terminal rod was placed on the center of the chimney, and insulated from it. The lightning discharge struck the chimney, destroying three of the pinnacles, which, falling through the roof below, did considerable damage. The air terminal was bent, and the composition on the point melted 3 in. The wires near the terminal point were likewise partly fused, and, on taking out one wire 25 ft. below the terminal rod, I found it so irregular in thickness that it had to be redrawn before the conductivity could be determined. On testing the earth terminal, I could get no deflection of the galvanometer needle, the conductor being buried in dry earth within a stone wall 8 ft. above the fosse, or asphalted area. The conductor on the tower had "good earth." The conductivity of the copper was 80·5.

In my recently published work on "The History and Application of Lightning Conductors," the following cases among others are given:

On the 6th of August, 1878, lightning struck the powder magazine at the Victoria Colliery, Burntcliff, Yorkshire. At the time of the explosion the magazine contained about 2,000 lb. of gunpowder. The magazine was an oblong building of brick, 9 ft. long, 5 ft. wide, and 6 ft. high (internal dimensions), and it had a uniform thickness of three bricks. At the end was a heavy iron door, and at the other a lightning conductor, consisting of a copper wire rope seven-sixteenths of an inch in diameter. The point of the terminal rod was about 13 ft. above the top of the building, and a similar length was carried into the ground, and terminated in clayey soil at a depth of 3 ft. The conductor was fixed to a pole distant about 2 in. from the end of the building opposite to that in which the iron door was fixed. *It was not connected with the iron door in any way.* On testing the conductivity of the copper rope it was found to be only 39·2 instead of 93 or 94 per cent. The conductor should not have been insulated, but brought down the pole, carried along the roof down the iron door post, and so into the ground.

In August, 1879, lightning struck one of the pinnacles of the tower of Cromer Church, Norfolk, although on another pinnacle only 27 ft. 6 in. distant, a good copper conductor, having a diameter of ⅝ of an inch was placed. On testing the conductor by means of a galvanometer, I found it and the earth connection in thorough order. In this case, a point should have been placed on each of the pinnacles, and joined the main conductor.

In May, 1879, the steeple of the church at Laughton-en-le-Morthen was struck by lightning and damaged. The spire, 175 ft. in height, had attached to it a thin tube made of corrugated copper, about ⅞ of an inch in external diameter, and ⅝ internal; the copper being 1-32 of an inch in thickness. It was made in short lengths joined together by screws and coupling pieces, but there was no metallic contact whatever between the pieces, which were much corroded. The conductor was not in contact with the building, but was kept at a distance of 2½ in. by twenty-one insulators. The earth contact was obtained by bending the tube and burying it in the ground at a depth of from 6 to 18 in., the soil being dry loose rubbish, the earth terminal being only 3 ft. It was placed in a corner formed by a double-stem buttress, which came between the conductor and a lead-covered roof attached to the spire; the distance between the conductor and the lead roofing being about 6 ft. 6 in The lightning appears to have come down the conductor a certain distance, and finding the road to earth bad, it passed through the buttress, dislodging about two cartloads of stone, and then down the cast iron pipes leading from the lead covered roof, and so to earth.

From the instances quoted, it is evident that it is not sufficient merely that rods of copper should be attached to a building, but it is necessary that once put up, they should be regularly inspected to see if they are in good order, so as to be really efficacious. That this is rarely done is one of the main reasons why accidents by lightning occur in places nominally protected by conductors. It is, perhaps, not too much to assert that at present not one in a thousand of our public buildings in England are regularly tested.

There can be no manner of doubt that in the matter of lightning conductors they manage things better on the other side of the Channel than with us. The French Government are in the constant habit of consulting the most eminent scientific men on the subject of protecting public buildings against the destructive influence of lightning. There is scarcely an instance in which a British Government ever did such a thing. It is true the Houses of Parliament had lightning conductors erected upon them at a very great cost and under scientific advice. But all who understand the subject practically agree in saying that it is very doubtful whether the magnificent pile of buildings in which our legislators assemble is really, that is efficiently, protected. At all events, I understand the earths have never been tested since the conductors were erected in 1852. That the Victoria Tower should have been struck in June, 1868, and slightly damaged, tends to show that the conductors at that time were not in an efficient state.

From the examination I have made I am pretty correct in stating that one-half of our cathedrals and three-fourths of our churches have not even nominal protection. For all that science has done, the Queen may any day be killed in her apartments in Windsor Castle, the Prince of Wales in Marlborough House, and the Prince Minister in Downing Street. To see the difference between England and France in this respect, one has but to cross the Channel between Dover and Calais. At Dover there are huge barracks of great length, on the top of high hills, exposed to the full fury of storms sweeping across the Channel, and the few conductors to be found upon them at long intervals are certainly not numerous enough for efficient protection against lightning, and their efficiency has never, so far as I can learn, been tested. The contrast in this respect on crossing the Channel is the most striking. At Calais the Hotel de Ville, in the Grand Place, literally bristles with lightning conductors, and so all the churches and chief buildings in the town. The same all over France, Germany, and Belgium. Without slavishly imitating our scientific neighbors, we might yet bestow some of the care they do upon the protection of our property as well as of our lives against the terrible effects of the electric force.

* Read before Section A of the British Association at Swansea, Aug. 27, 1880.

ON THE PROPER FORM OF LIGHTNING CONDUCTORS.*

By William Henry Preece.

A lightning conductor erected for the protection of a building consists of a ribbon, rod, chain, rope, or other mass of metal attached to the highest point of the structure and descending to the earth. What shall be the form of this conductor? has been a vexed question from the days of Franklin to the present. Shall it be dependent on extent of surface or on sectional area? In other words, does the transference of electricity when the potentials are so high as to cause lightning discharges, obey the law of Ohm, or is this modified by the presence of some fresh condition? Snow Harris was a very warm advocate of the surface form. He used flat ribbons for his ships and tubes for his buildings. Henry, of Washington, believed in the efficacy of surface. According to him, frictional electricity passes at the surface, galvanic electricity through the mass. M. Melsens is found on the same side, and Guillemin, of Paris, led many French electricians to favor the same view.

On the other hand, Faraday almost angrily espoused the opposite side. "As respects electrical conduction," said he, "no advantage is gained by expanding the rod horizontally into a strap or tube. Surface does nothing; the solid section is the essential element."

The advocates of the solid and cylindrical form argue that the lightning conductor is simply a path by which electricity is transferred from a point of high potential (an electrified cloud) to a point of lower potential (the earth), and that its efficacy depends solely upon its resistance. It obeys the law of Ohm, and its efficacy is therefore for the same material dependent on its mass and sectional area.

The advocates of surface argue that, as in all cases of static charge electricity exists only on the surface, so when electricity of "high tension" is conducted away it is the surface that plays the prime part, and, therefore, the greater the surface the easier the path to the discharge. Again, they say when a cylindrical conductor conveys a charge of electricity it is raised to a "high tension," and is rendered capable of doing mischief; but with the same charge, the greater the surface the less the density on the surface, and, therefore, the greater the safety. In other words, with a given quantity of electricity, the greater the surface the less the potential. Moreover, they urge, since, according to Guillemin, currents of electricity flowing in the same direction retard each other with the power varying with the distance separating them, and since a rod may be considered as a bundle of smaller but parallel rods, so a current of electricity may be considered as being made up of many parallel currents, each retarding the other. Hence, a ribbon will conduct better than a rod, because the currents are spread further apart, and retard each other less. These arguments have led to the employment of unsightly ribbons and expensive tubes, which have considerably interfered with the establishment of this very necessary element of safety to buildings.

The arguments in favor of the surface form are, in the opinion of the author, deductions of exploded theories, from imperfect experiments, or from erroneous interpretations of well-ascertained facts. No direct experiments have ever been made to solve the question, as far as the author knows. Quantities of electricity, that is, static discharges from condensers, are in incessant use for telegraphic purposes, and are found to follow exactly Ohm's law, even with the most delicate apparatus. The knowledge of the flow of electricity through conductors, of retarding influence of electro-static capacity upon this flow, and of the distribution of charge, has become so much greater of late years through the great extension of submarine telegraphy and the labors of Sir William Thomson, Clerk-Maxwell, and others, that I question if any English electrician would now be found to argue in favor of the surface form. Nevertheless, ribbons and tubes still continue to be used, and it appeared very desirable to settle the question experimentally. I determined to try and do so.

FIRST EXPERIMENTS, JUNE 28, 1880.

Dr. Warren de la Rue, who is always ready to place his splendidly-equipped laboratory at the service of science, not only allowed me to use his enormous battery and his various appliances, but aided me by his advice, and assisted me in conducting the experiments.

Copper conductors, 30 feet long, of precisely the same mass, (*a*) drawn into a solid cylinder, (*b*) made into a thin tube, and (*c*) rolled into a thin ribbon, were first of all obtained. The source of electricity was 3 240 chloride of silver cells. The charge was accumulated in a condenser of a capacity of 42·8 microfarads. It was discharged through platinum wire of 0·0125 diameter, of different lengths. The sudden discharge of such a large quantity of electricity as that contained by 42 8 microfarads raised to a potential of 3,317* volts is very difficult to measure. It partakes very much of the character of lightning. In fact the difference of potential per unit length of air is probably greater than that of ordinary lightning itself. It completely deflagrates 2¼ inches of the platinum wire, but by increasing the length of the wire it could be made to reproduce all the different phases of heat which are indicated by the various shades of red until we reach white heat, fusion, and deflagration. Hence the character of the deflagration, which is faithfully recorded on a white card, to which the wire is attached, by its scattered particles, is a fairly approximate measure of the charge that has passed, while the length of wire, raised to a dull red heat, is a better one, for any variation in the strength of the current within moderate limits is faithfully recorded by the change of color.

Experiment 1.—Similar charges were passed through the ribbon, tube, and wire, and in each case 2½ inches of wire were deflagrated. No difference whatever could be detected in the character of the deflagration.

Experiment 2.—Ten inches of wire were taken and similar charges passed through. In each case the wire was raised to very bright redness, bordering on the fusing point, and in two cases the wire broke. In each case the wire knuckled up into wrinkles, and gave evidence of powerful mechanical disturbance. The same wire was not used a second time. No difference could be detected in the effect through the different conductors.

Experiment 3.—Silver wire of the same diameter and length was used, and similar charges transmitted through it. Redness was barely visible, but the behavior of the wire was similar in each case.

The conclusion arrived at unhesitatingly was that change of form produced no difference whatever in the character of the discharge, and that it depended simply on mass.

SECOND EXPERIMENTS, JULY 19, 1880.

As it might be urged that the length of conductor tested was so short, and its resistance so small that considerable variations might occur and yet be invisible, similar lengths (30 feet) of lead—a very bad conductor, its resistance being twelve times that of copper—were obtained, drawn as a wire, made as a tube, and rolled as a ribbon, each being of similar weight.

Experiment 4.—Charges from the same condenser, 42·8 microfarads, but with 3,280 cells, were passed through, and the discharges observed on 6 inches of platinum wire 0·0125 inch diameter, which in each case was heated to bright redness. No variation whatever could be detected, whether the wire, the tube, or the ribbon was used.

Experiment 5.—In order to form some idea as to how closely we could estimate any variation in the character of the discharge, we used a long piece of platinum wire, and adjusted the lengths until we obtained just visible redness; then a diminution of ten per cent. (3 feet) produced a marked change to dull redness, and further excisions raised the temperature to brighter and still brighter red.

The conclusion arrived at was that any change in resistance of five per cent. would have been clearly and easily discernible.

It therefore appears proved that the discharges of electricity of high potentials obey the law of Ohm, and are not affected by change of form. Hence, extent of surface does not favor lightning discharges. No more efficient lightning conductor than a cylindrical rod or a wire rope can, therefore, be devised.

* Read before the British Association, 1880.

AN ELECTRO-DYNAMIC PARADOX.

By M. Gerard-Lescuyer.

Dynamo-electric machines, of which the Gramme machine is the most common type, are reversible—that is to say, if they are traversed by a current they produce motion, and may serve for the transmission of force. Under similar conditions magneto-electric machines with constant currents possess the same properties. But if the current produced by a dynamo-electric machine is passed into a magneto-electric machine, a novel phenomenon is produced. As soon as the circuit is closed the electro-magnetic machine sets itself in motion, and takes a regular speed in proportion

* The electromotive force of the chloride of the silver cell is 1·09 volt.

to the intensity of the current which excites it; suddenly it slackens, stops, and begins to move in the opposite direction, then stops anew, and turns in the same direction as at first. It is animated with a regular alternative movement, which continues as long as does the exciting current. The author explains these phenomena by supposing that the electro-magnetic machine gives rise to a special current, which in turn traverses the dynamo-electric machine in the inverse direction, reversing the polarities of the inductors and generating a new current.

SOLVAY'S AMMONIA-WATER CONCENTRATOR.

HITHERTO when it has been desired to obtain a continuous and methodical operation of distilling apparatus, it has been customary to combine vertical apparatus composed of superposed compartments, the vertical arrangement being the only one that readily favors the flow of a liquid in a direction contrary to that of the vapors, and which is an essential condition. The consequences of such an arrangement are the following: (1.) The impossibility of employing direct heating, it being necessary to effect the distillation by means of steam employed in the interior of the apparatus and mixed with the vapors of distillation. (2.) The necessity of raising the liquid to a certain height in order to introduce it into the apparatus. (3.) The difficulty of access to the apparatus for the purposes of inspection.

The first of these inconveniences is the greatest; for, besides necessitating the location of a steam generator in establishments that have no excess of steam at their disposal, it also renders the operation of the apparatus less economical. The apparatus invented by M. Solvay, and of which numerous applications have already been made in the arts—especially in the distillation of ammoniacal waters, where it presents peculiar advantages—is arranged horizontally and heated by direct contact with the fire. This apparatus is particularly remarkable in the principle that it involves, and the result of which is that the vapors produced cause the liquid to advance horizontally in a direction contrary to that of such vapors and their pressure. When a gas or steam, or a vapor of any kind, circulates through a vertical pipe, it may carry with it a certain quantity of liquid in the form of priming; and if the mass is sufficiently great with respect to the mass of the liquid, and the velocity is adequate, the liquid may be raised to a height much greater than that due to the presence of the gas or steam. The arrangement of M. Solvay's distilling apparatus, which utilizes this property, is represented in the annexed engravings. It consists of a boiler, A (Fig. 1), divided into a certain number of compartments, B, by partitions, C. Each compartment contains a vessel, E, which communicates with the contiguous compartment which succeeds it, and thus the liquid from the latter enters this vessel. On the other hand, the vapors from the preceding compartment enter the vessel, E, through the plunge-pipe, T. The fireplace is located at F. These details being given, the operation of the apparatus is easily understood.

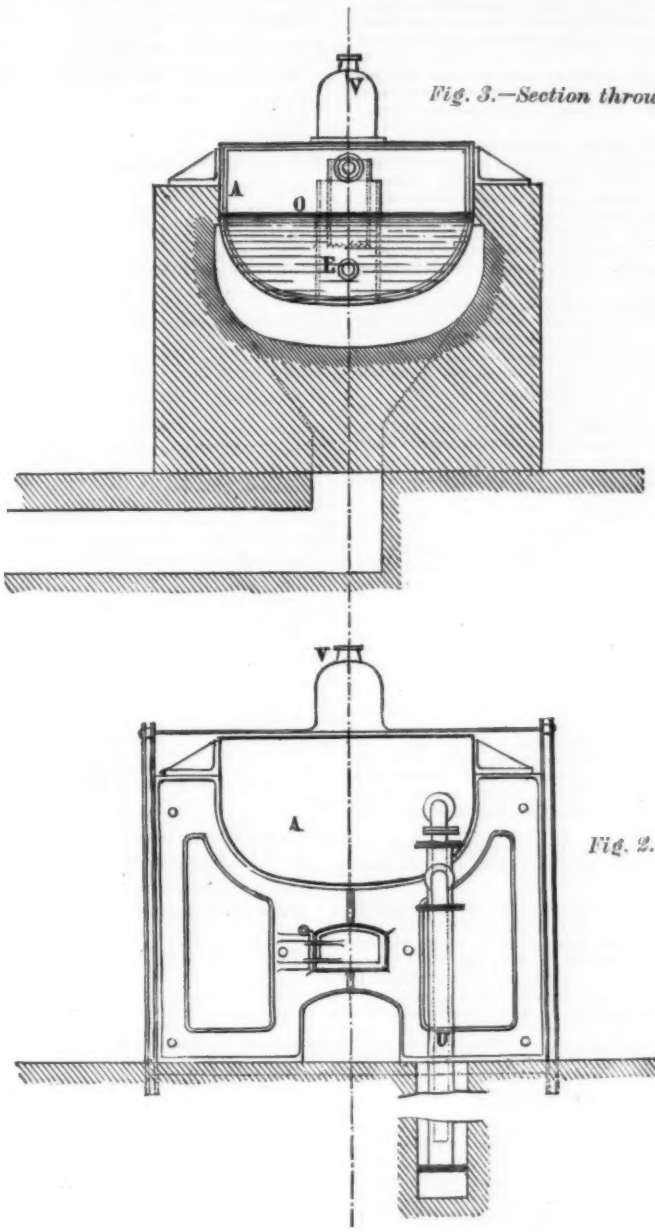


Fig. 3.—Section through E F.

Fig. 2.—Front View.

SOLVAY'S AMMONIA-WATER CONCENTRATOR

Let us suppose the boiler to be filled to a uniform level, O. The liquid to be distilled, having been first heated in the apparatus, R (as will be explained further on), enters the boiler, A, through the pipe, M, and from the compartment, B, enters the vessel, E'. Then the vapors given off from the compartment, B^3, through the plunge-pipe, T, drive some of the liquid out of the vessel, E', and send it into the compartment, B'. The liquid then advances thus from compartment, B, into compartment, B', in consequence of the outflow of the vapors from compartment, B^3. In the same way this liquid passes on to compartment, B^2, through the outflow of the vapors which are disengaged from the compartment, B^2; so that, finally, the liquid will issue distilled from compartment, B^{12}, through the tube, U. The vapors which are given off escape through V.

If a gas were to be washed it would enter, then, through compartment, B^{12}, and the washing liquid would enter through compartment, B.

R is an apparatus for condensing vapors proceeding from distillation. These vapors, being led into the worm, I, are condensed by the very waters that are to be distilled, and which enter cold from the reservoir, K, after first passing through a small washing apparatus, Q. From the condenser the liquid enters the boiler through M, as already explained. The apparatus is also provided with a feed regulator (not shown in the cut), which, through the temperature of the feed waters (before they enter the boiler), regulates the admission in such a manner as to restore to the boiler *at every instant* a quantity of water corresponding to the vapors produced. The apparatus, as thus constructed, has been applied in numerous instances to the distillation of ammoniacal waters. The type in use distill, per twenty-four hours, 12, 24, and 48 cubic meters of ammoniacal waters at about 3° Baumé, and convert them into fifteen or twenty per cent. ammonia waters (easy of transportation to any distance) by the use of forty-five to sixty five pounds of coal per cubic meter distilled. When the ammoniacal waters contain a remarkable proportion of fixed salts, these, too, may be distilled in the apparatus; but in this case the latter must be modified in such a way that, when the volatile acid products are disengaged, the liquid may pass for a moment into a special lime compartment, where it may combine with the necessary quantity of lime without carrying out any of the latter along with it in its process of distillation in the remainder of the apparatus. The apparatus is claimed to be cheap, very economical, and very regular in its operation.

A NEW IMPROVEMENT IN MINERAL ANALYSIS.

MR. C. J. MULLER has employed in connection with the blow-pipe open and closed glass tubes for mineral analysis, and has obtained very important results in heating the minerals in these tubes. The glass tubes must be made of Bohemian crystal, in order not to soften by the action of the heat, or to discolor, as usually happens with flint glass in consequence of the formation of a deposit of reduced lead. The most convenient dimensions for the closed tubes are 3 inches by 0·3 or 0·4 inch, and for the open tubes 4 inches by 0·05 to 0·2 inch.

In experimenting with the closed tubes the following phenomena have to be observed: 1, decrepitation; 2, changes of color; 3, phosphorescence; 4, deposit of condensed vapor of water; 5, deposit of solid sublimated substance; 6, fusion; 7, the production of a gas or vapor, which may be colored, odorous, alkaline, or acid. Sometimes it is advantageous if the tube ends in a swelling. Before using these tubes they have to be thoroughly cleansed and afterwards dried over an alcohol lamp. According to the requirements the substances for assaying have to be either in fine powder or very small fragments. If powder is used, great care must be taken in introducing it into the tube that none of it clings to the walls of the tube. The tube which

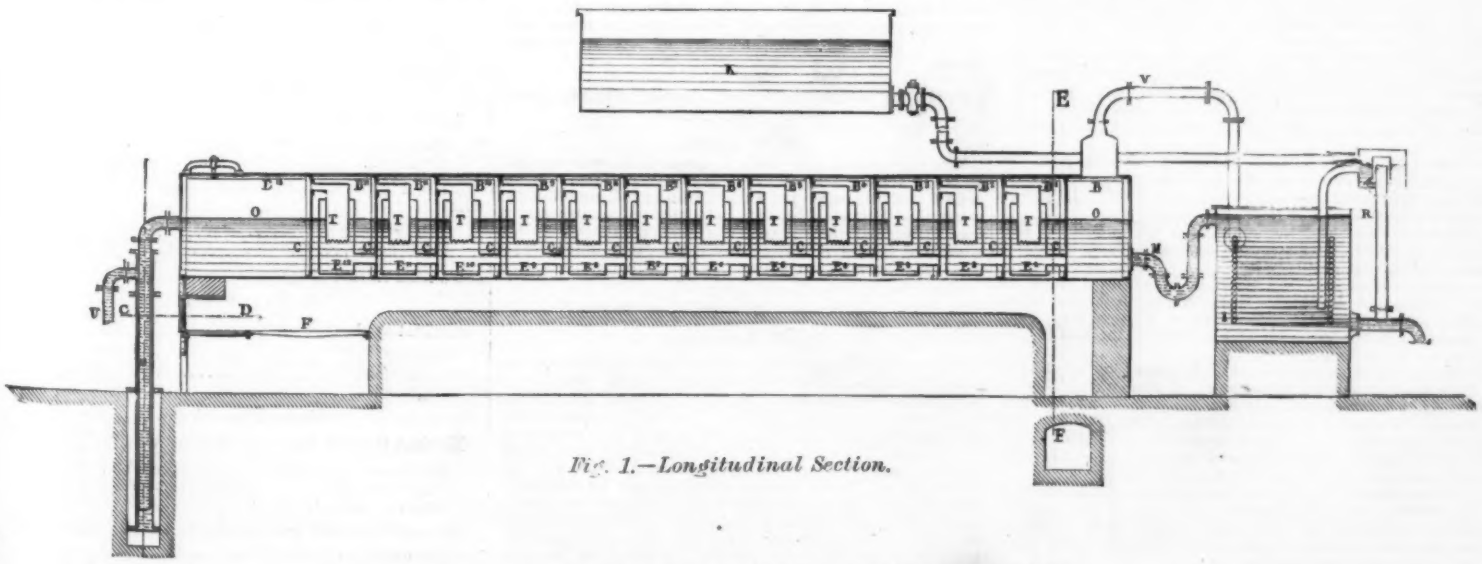


Fig. 1.—Longitudinal Section.

SOLVAY'S AMMONIA-WATER CONCENTRATOR.

contains the substance has first to be heated over an alcohol lamp, but in most cases the temperature will have to be afterwards elevated by exposing the tube to the flame of a blow pipe. In order to detect whether the vapor is acid or basic small pieces of test paper have to be introduced into the entrance of the tube.

The following reactions of minerals have been ascertained by this method.

Wilherite.—Heated in a glass tube over an alcohol lamp, the substance decrepitates and produces an aqueous vapor, which condenses in the upper part of the tube.

Gypsum.—If heated over an alcohol lamp and afterwards by means of the blowpipe, it becomes white and is transformed to plaster of Paris. The water condenses in the upper part of the tube. This reaction is characteristic for gypsum.

Spath-Fluor.—Heated over an alcohol lamp it becomes phosphorescent in the darkness, decrepitates and disengages sometimes a little water. This reaction is also characteristic.

Natural Alum.—Heated by means of the blow-pipe, first slightly, afterwards stronger, it swells up and disengages a great deal of water. At a high temperature it produces sulphuric acid, reddening the test paper.

Turquoise.—Heated over the alcohol lamp it disengages water, becomes black, and sometimes decrepitates.

Wavellite.—Heated by means of the blow-pipe it develops water and hydrofluoric acid, which eats into the glass, proving the presence of fluor.

Iron-Pyrites.—When heated by the flame of the blow-pipe it sets free a great deal of sulphur and sulphureted hydrogen, which may easily be recognized by its smell and its action upon paper saturated with acetate of lead.

Mispickel.—Heated by means of the blow-pipe it produces a red sublimate of bisulphuret of arsenic and also of metallic arsenic.

Pyrolusite.—When strongly heated by means of the blow-pipe it sets free the oxygen, which is recognized by its action upon a small piece of burning charcoal, which is introduced into the tube.

Disomose (nickel glance).—Heated by means of the blow-pipe it decrepitates and gives a red yellow sublimate of trisulphuret of arsenic.

Ullmanite.—Heated by means of the blow-pipe it produces a white sublimate of antimonious acid and sometimes some trisulphuret of of arsenic.

Calamine.—Strongly heated by means of the blow-pipe it sets free carbonic acid, which may be recognized by introducing a burning match into the tube, which will be extinguished.

Jamesonite.—Heated by means of the blow-pipe it melts and produces sublimate of sulphur, sulphate of antimony, and metallic antimony.

TIN CRYSTALS.

Muriate of Protoxide of Tin.

This salt, which is the subject of a considerable trade, is obtained by several reactions: 1st, by dissolving anhydrous stannous chloride; 2d, by dissolving metallic tin in commercial muriatic acid; 3d, by dissolving an excess of tin in *aqua-regia* containing an excess of muriatic acid; and 4th, by the action of an excess of tin upon the dissolved bichloride of tin.

Of all these methods one only is in industrial use—the dissolving metallic tin in muriatic acid.

The tin is granulated by pouring it when melted into cold water.

The solution is effected in stoneware vessels heated in the water bath, or in copper pans free from soldering and brazing, and riveted with the same metal. These copper pans may be heated over the naked fire, or they may be fitted with steam jackets. As long as there is tin in excess the copper is not attacked by the acid, and the electric current produced causes the tin to dissolve more quickly in copper vessels than in those of stoneware.

Two parts of commercial muriatic acid are generally employed for one of tin. Action begins in the cold; but it soon slackens, and the heat is gradually raised.

The vessels, whether copper or stoneware, should be covered, and the collected gases should be led into a flue, after passing through two or three small coke towers to arrest the muriatic vapors, which carry away mechanically a little tin. Toward the end nothing but hydrogen should escape.

When the solution marks upward of 170° Tw., the action is stopped, and the liquid drawn into earthen crystallizing pans. After cooling and crystallization the pans are drained, and the salt dried in the shade. Light colors tin crystals by facilitating the formation of an insoluble yellow oxychloride.

Tin salts crystallize in two forms—the octahedral and the prismatic. Some dyers prefer the former and some the latter kind; but, in our opinion, there is no difference. This difference in crystallization depends upon manipulation. Tin crystals ought to contain fifty-two per cent. of metallic tin.

The commercial crystals retain always sensible quantities of iron, which is not to be wondered at. They are made with a very impure muriatic acid, colored strongly yellow with perchloride of iron (ferric chloride).

If, notwithstanding, the salt of tin is white, it is because iron is present in the form of the protochloride (ferrous chloride), which is almost colorless.

We have never seen any notice taken of the iron in tin crystals, and in our opinion this is wrong in certain cases. In its action upon the natural coloring matters very small quantities of iron are sufficient to sadden the shades produced.

The purity of tin crystals may be found by treating it with an excess of hydrosulphate of ammonia. There is formed at first a chocolate-brown precipitate, which redissolves in the excess of hydrosulphate. The iron and lead form black sulphurets, which remain insoluble, and which may be removed by filtration and washing upon the filter with water mixed with hydrosulphate of ammonia.

In the filtered liquid will be found all the tin, which is not likely to be contaminated with any of the common metals, except antimony, the sulphuret of which is likewise soluble in excess of hydrosulphate of ammonia. But this is an impurity little to be expected.

Tin crystals are very soluble in water, and on dissolving they produce a considerable fall of temperature. By an excess of water they are decomposed into an acid salt, which dissolves, and a sub-salt, which becomes insoluble. An addition of an acid prevents this decomposition, as also does an alkaline chloride or sal-ammoniac.

Tin crystals form in effect very stable double salts with the chlorides of potassium, sodium, and ammonium.

It is not possible to completely expel the water from tin crystals by evaporation. It is partly decomposed, and there remains an oxychloride of tin.

Tin crystals are very greedy of oxygen; on exposure to the air the crystals turn yellow, and are partly transformed into oxychloride, while the solutions are rendered turbid by the formation of a similar product.

Nevertheless, though greedy of oxygen, more than a year elapses before the oxidation is complete.

The salt of tin is a powerful reducing agent. In presence of an excess of hydrochloric acid, and of reducible oxygenated bodies, such as the nitric, chromic, chloric, manganic acids, etc., it is transformed into perchloride (permuriate or oxymuriate).

It is also very greedy of chlorine, and absorbs this gas with rapidity and with a rise of temperature. It reduces the bichloride of mercury, the perchlorides of copper, iron, etc.

In fine, it may be said that the protochloride of tin, under suitable conditions, has a tendency to pass into perchloride. If there is only oxygen present, or an insufficient quantity of chlorine, there are produced various oxychlorides, soluble or insoluble, according to their mode of production; they are generally yellowish, but sometimes white.

An account of these oxychlorides would be of great practical interest, but it cannot yet be furnished. In our opinion they are of two kinds.

When they are soluble they may be considered as mixtures of stannic acid and of protochloride; when insoluble they are mixtures of metastannic acid and of protochloride.

It is, however, very difficult to determine the capricious conditions in which there is produced sometimes a stannic and sometimes a metastannic oxychloride.

To conclude this account of the salt of tin, there only remains to notice its reaction upon natural coloring matters; upon most of the artificial dyes it has no action, except when it behaves as a reducing agent.

Madder.—Brownish precipitate. The liquid retains a reddish-yellow-brown color.

Logwood.—Violet precipitate.

Brazil Wood.—Bright rose precipitate.

Sanders (Alcoholic decoction).—Blood-red precipitate.

Cochineal.—Violate precipitate. If the salt of tin is acid, the solution turns yellow, and there is formed a cherry-colored precipitate.

Turmeric.—Red-brown precipitate.

Quercitron.—Reddish precipitate.

Fustic.—Yellow precipitate.

Young Fustic.—Flocky orange-reddish precipitate.

Weld.—Copious yellow precipitate.

Persian Berries.—The liquid turns a greenish yellow; slight precipitate.

Annatto.—Lemon-yellow precipitate.

We only give the characteristic reactions used in dyeing for fixing or developing colors. There are some without any interest; but we may mention the reducing action of the protoxide of tin upon indigo, which has been utilized in preparing indigo for printing.

The action of tin crystals upon tannins is very remarkable, and has been used for fixing them upon the fiber. —*Teinturier Pratique.*

[This article calls for some remarks. It is an exaggeration to say that the presence and the mischievous effects of iron in tin crystals or in tin mordants has been overlooked. The writer, in his turn, overlooks the fact that tin crystals may possibly contain sulphates of zinc or of magnesia. If a salt of zinc is present in tin crystals, it will be precipitated by hydrosulphate of ammonia along with the iron and lead (if any), and, like them, will not dissolve in excess. But the precipitate formed will be white, not black].—*Chemical Review.*

FIREPROOF MATERIALS.

In the report published by the *Journal* on the Applied Science Exhibition, Paris, of last year, mention was made of the muslin curtains shown by M. A. J. Martin, Paris, to which a flame was constantly applied without consuming them. The composition he employs for rendering inflammable paper, wood, and textile fabrics is the following:

	Parts.
Pure sulphate of ammonia	80
Carbonate of ammonia	25
Boracic acid	30
Pure borax	17
Starch	20
Distilled or pure water	1,000

The materials are dipped in this solution while hot, so as to be thoroughly impregnated, when they are dried sufficiently to be ironed in the same way as ordinary starched fabrics.

DESTRUCTIVE ACTION OF WOODY FIBER UPON SALICYLIC ACID.

By H. Kolbe.

The attempt has been made to preserve the water supply on board ship by a small addition of salicylic acid. It appeared that the acid was entirely destroyed, and that the water then became offensive. On further examination, it was found that the salicylic acid is not absorbed by the wood, but destroyed. The result is similar if salicylic acid is added to wine in the wood.

SOLUTION OF CHLORINE IN WATER.

By M. Berthelot.

At one and the same temperature water dissolves proportions of chlorine, which vary according to the duration of contact and the intensity of the light. The variations in the heat evolved during the solution of one and the same weight of chlorine in water are considerable, as it may range from + 1·50 to 3·77 cals., the first figure answering to a simple solution, and a second to a decomposition of the water by the chlorine. The displacement of oxygen by chlorine is effected much more distinctly with hydrogen peroxide, a reaction which is explained very simply on thermo-chemical principles. The solubility of chlorine in concentrated solutions of earthy chlorides is less than in water, but increases with dilution. In concentrated hydrochloric acid chlorine dissolves much more plentifully than in water, and with a greater liberation of heat—facts which render probable the formation of a peculiar combination between chlorine and hydrochloric acid.

FAST SHADES ON WOOL.

Lead Gray for 220 *lb.*

Boil for an hour with

Logwood	22 lb.
Sumac	4 lb. 6 oz.
Turmeric	1 lb. 1½ oz.
Argol	4 lb. 6 oz.
Alum	1 lb. 1½ oz.

Toward the end of the time sprinkle the wool, turning it continually, with the solution of

Copperas	17½ oz.

and boil still for half an hour.

Solid Maroon for Wool and Woolen Warns (110 *lb.*).

Young fustic in a bag	17½ lb.
Logwood	5 lb. 7 oz.
Orchil	2 lb. 3 oz.

Make a decoction, and add to it the decoction of

Camwood or sanders	15 lb. 5 oz.
Madder	22 lb.
Sumac	13 lb. 2 oz.
Argol	4 lb. 6 oz.

Work in this beck at a boil for an hour, and then add

Bluestone	2 lb. 3 oz.

Boil for half an hour, and sadden with

Copperas	2 lb. 3 oz.

Lastly, top with

Ammonia	2 lb. 3 oz.

Black on Wool (22 *lb.*).

Flannels are often made in black and red with black and white wool, dying afterward a scarlet. Otherwise the wool is taken vat blue and white. The pieces are then dyed scarlet and come up red and black. A black for this purpose must be able to resist the scarlet dye to follow, and differs essentially from common blacks.

The dye is made up as follows:

Logwood	35 lb.
Fustic	11 lb.
Argol	4 lb. 6 oz.
Alum	2 lb. 3 oz.

Work in this bath at a boil of 90 minutes, and sadden in the same with the addition of

Copperas	4 lb. 6 oz.
Bluestone	17½ oz.

Boil for half an hour.

For scarlet dyeing proceed gently, and do not let the pieces remain more than half an hour in the cochineal bath.

A chrome black must not be used for the tin crystals, and the oxalic acid would turn it to a violet or a brown.

Ash Gray for Wool and Yarn (167 *lb.*).

Boil for an hour and half with

Bichromate of potash	2¾ lb.
Sulphuric acid	3¼ lb.

Let cool in the flot, lift, and dye in a fresh water with

Logwood	7 lb. 10 oz.
Sumac	2 lb. 3 oz.
Carmeloine	1 lb. 1 oz.

Boil for an hour and sadden with

Copperas	2 lb. 3 oz.
Argol	2 lb. 3 oz.

Golden Maroon (334 *lb.*).

Mordant for an hour and a half with

Bichromate of potash	6 lb. 9 oz.
Sulphuric acid	3¼ lb.
Alum	6 lb. 9 oz.
Oxalic acid	17½ oz.

Dye in a fresh water with the decoctions of

Young fustic	66 lb.
Logwood	6 lb. 4 oz.
Carmeloine	6 lb. 4 oz.
Orchil	13 lb. 2 oz.

Let the decoction cool, enter the mordanted goods, and boil for an hour. Sadden in the same bath with

Copperas	4 lb. 6 oz.
Bluestone	27¾ oz.

Work for half an hour and rinse.

Tea Shade (55 *lb.*).

Mordant at a boil for an hour with

Bichromate of potash	17½ oz.
Argol	2 lb. 3 oz.

Let cool in the flot, and dye in a fresh water for an hour with

Young fustic	2 lb. 3 oz.
Carmeloine	8½ oz.

and a little extract of indigo.

Dead Leaves (55 *lb.*).

Mordant as above, and dye with

Catechu	6 lb. 9 oz.
Young fustic	4 lb. 6 oz.
Logwood	2 lb. 3 oz.

Marine Blue (264 *lb.*).

Mordant at a boil for ninety minutes with

Bichromate of potash	4 lb. 6 oz.
Sulphuric acid	6 lb. 9 oz
Argol	9 lb. 13 oz.

Let cool in the flot, and dye at a boil for an hour with

Logwood	55 lb.
Extract of indigo	4 lb. 6 oz.

—*Teinturier Pratique.*

HELVETIA GREEN.

THIS color, invented by Otto Fischer, of Munich, and manufactured by Bindshedler & Busch, of Bale, is prepared as follows:

One hundred parts dimethylaniline, forty parts oil of bitter almonds, and one hundred parts of solid chloride of zinc are heated together in the water bath. As soon as the odor of bitter almonds has disappeared the product of the reaction is rendered alkaline with caustic soda, and any undecomposed ingredients are driven off with steam. On cooling tetramethyldiamidotriphenylmethan (what a preposterous name!) congeals, and is obtained pure by recrystallization from alcohol.

The next step is to prepare the sulpho-acid of this long-winded compound. One hundred parts thereof are heated on the water bath in five hundred parts of oil of vitriol, or an equivalent quantity of the fuming acid, till a specimen dissolves entirely in alkaline water. The whole is then poured into water, and the soda salt of the sulpho-acid is obtained by neutralizing with caustic soda. This solution is then submitted to oxidation by treatment with the theoretical proportion of peroxide of lead or maganese in a weak acetic acid.

Thus, the solution of the soda salt of the sulpho-acid obtained from one hundred parts of the above unmentionable compound is slightly acidified with acetic acid, and slowly mixed in the cold with seventy-five parts of oxide of lead (the so-called pure oxide). The precipitate formed is collected on a filter, neutralized with dilute soda lye, and filtered at a boil. The liquid is concentrated by evaporation, and, on cooling, the soda salt of the new coloring matter separates out. From this compound the free sulpho-acid is easily obtained by treatment with dilute muriatic acid.

The *Chemiker Zeitung*, after describing the above process, remarks that Helvetia green is a very pretty product, and in its properties closely resembles the dyes prepared by various German firms by sulphurizing the green when previously formed. But it shares the same drawback that its tinctorial power is low. As bitter-almond green (benzoyl green) is capable of working on to the fiber in an acid flot, the scope for a sulpho-acid is far more limited than it would have been in the days of methyl green, which dyes only in a perfectly neutral bath.—*Chemical Review.*

BLEACHING JUTE.

JUTE has little power of resisting the action of alkalies and acids. It cannot, like linen, hemp, and cotton, be boiled with soda-ash. Under the influence of alkalies its natural gray color passes to a reddish brown, and its filaments are very rapidly disaggregated. Acids, even if used in very weak solutions, attack it still more fundamentally. Chloride of lime may be used without risk so long as the bleaching of the jute is effected by a complete immersion in the bleach liquor.

The treatment of jute by complete immersion with exclusion of air is the safest; treatment on rollers with intervention of air is the most dangerous. This is easily understood, because in the former case the bleaching is a slow oxidation, while in the latter case it is the result of the rapid and energetic action of hypochlorous gas.

An attempt has been made, but without much success, to use silicate and chloride of soda. Chloride of lime is preferable. But to produce good whites the jute should be alternately steeped in soap-lyes and in chloride of lime.

The following instructions are for the production of a creamy shade:

Steep the jute in a weak, lukewarm soap-beck for ten minutes.

After draining, steep the jute for forty minutes at most in a beck of chloride of lime, not marking more than half a degree Tw.

The length of the immersion varies; the quality of the jute and the shade which is to be produced are the best guides. As for whites more complete than a cream shade, they are obtained in the same manner, but by lessening the length of the immersions in the soap and chloride of lime baths and repeating them several times in succession. The number of the operations depends consequently on the degree of whiteness to be attained.

Whatever may be the shade at which we stop, it is well to finish by two successive washings—the one with lukewarm and the other with cold water. Nothing further is then needful but to drain and dry at the lowest temperature possible. —*Teinturier Pratique.*

METHOD OF DETERMINING THE FREE FATTY ACIDS PRESENT IN COMMERCIAL OILS.*

By M. CARPENTIN.

THE author, after having criticised the analytical process of Burstynn, gives the following process:

He takes a small flask with a flat bottom, or a medicine bottle, capable of holding 250 cubic centimeters.

He measures into this bottle 50 cubic centimeters of oil and 100 cubic centimeters of alcohol at 90 per cent., and adds three or four drops of tincture of turmeric. The bottle is stoppered and well shaken.

It is then placed under a Mohr's burette, containing a solution of 40 grammes of pure fused caustic soda per liter of water.

As forty parts of soda neutralizes 282 of oleic acid, one cubic centimeter of the standard liquid, containing 0·04 gramme of soda, corresponds to 0·282 gramme of oleic acid.

The solution of soda is let flow little by little into the bottle, which is shaken. When a red coloration appears it is stoppered and shaken for a long time, when the canary-yellow color is re-established, because the alcohol has drawn out of the oil a further quantity of acid.

This process is repeated until the red color is permanent.

Nothing now remains but to read off on the burette the exact quantity of the soda solution used, and to multiply it by 0·282 gramme. We obtain thus the quantity of free oleic acid contained in the sample under examination.

There is no reason to fear that a part of the soda may serve to saponify the oil in this operation, performed as it is in the cold, and in an alcoholic medium, which dissolves less than a thousandth of oil.

On operating upon a neutral virgin oil, or upon an oil artificially neutralized, we find that the first drop of the alkaline liquid reddens the turmeric.

By this process the author has always been able to determine quantities of oleic acid intentionally added to neutral oils.

An easy determination of fatty acids in oils is of importance on several accounts. It enables us to ascertain the degree of rancidity in eatable oils (salad oils, etc.), and thus fix their value more accurately than by the taste.

To recognize those faults in lighting oils which depend on the presence of free acids, which affect their illuminating power in a very disadvantageous manner.

To reject oils intended for lubricating machinery, if their acidity exceeds certain limits. It is now perfectly well known that free fatty acid diminishes the lubricating power of an oil, and has the serious defect of corroding the metals to which it is applied.—*Chemical Review.*

* Translated from the *Journal de Pharmacie et de Chimie.*

BLACK PAPER PULP.

By M. AUGUSTE ABADIE.

DARK and cheap colors, destined for wrapping papers, have been as yet little studied by those who have published treatises upon the coloration of paper pulp. Yet there are among such colors some which might be very serviceable to manufacturers who make wrapping papers: such are bottle-green, bright maroon, turkey red, black blue, and several others. These colors, though ordinary, take a brilliant tone when the paper is glazed.

The author gives nine shades of deep blues, from the lightest, which is of a greenish blue, to the darkest, which is a very fine and lively blue black. These colorations may be used with brown pulps, scarcely or not at all bleached, and unbleached, or made of straw, maize stems, furze, nettles, ferns, etc. The blue black is a mixture of blue vitriol, extract of logwood, and, in certain cases, of animal charcoal —all cheap products. The proportions are arranged for 100 parts of dry paper. No alum or sulphate of alumina must be employed to precipitate the substances of the sizing. For such papers imperviousness is of less consequence than pliability and smoothness.

No. 1.

Blue vitriol	1½ per cent.
Extract of logwood	3 " "

No. 2.

Blue vitriol	1¼ per cent.
Extract of logwood	2½ " "
Animal charcoal	⅛ " "

No. 3.

Blue vitriol	¾ per cent.
Extract of logwood	1½ " "
Salt	1½ " "
Animal charcoal	¼ " "

No. 4.

Blue vitriol	1 per cent.
Extract of logwood	2 " "
Animal charcoal	1½ " "

No. 5.

Blue vitriol	1 per cent.
Extract of logwood	2 " "
Pyroligneous acid	6 " "

No. 6.

Blue vitriol	1½ per cent.
Extract of logwood	3 " "
Animal charcoal	2 " "

No. 7.

Blue vitriol	1½ per cent.
Extract of logwood	3 " "

No. 8.

Blue vitriol	3 per cent.
Extract of logwood	4 " "

No. 9.

Blue vitriol	4 per cent.
Extract of logwood	6 " "

—*Teinturier Pratique.*

PREPARATION OF GLYCERINE FROM SOAP-BOILERS' LYES.

WITH reference to the patented process of Thomas, Fuller, and King, C. Deite writes to the *Chemiker Zeitung* as follows: The removal of caustic and carbonated alkali from the lye brings us not a step further. The result is merely a concentrated solution of salt in glycerine, and a remunerative extraction of the glycerine from such a mixture is not to be thought of. The patentees seem to have scarcely a notion of glycerine, or they would not say so simply: "The liquid obtained may be refined, distilled, or concentrated, as may be required." How is it possible to refine glycerine saturated with salt? As for distillation, every glycerine distiller knows that, on distillation with superheated steam, the chlorine compounds pass over also to a considerable degree.

Therefore, to obtain even a tolerably useful article, a repeated distillation would be needed, and an article like glycerine cannot bear this. We must never forget that crude glycerine is a by-product which is sold by the stearine manufacturers at exceedingly low prices, so that circumstantial and costly methods are out of the question.—*Chem. Review.*

LUMINOUS PAINT.

A CORRESPONDENT of the London *Design and Work* states that he has tried the following method of making luminous paint with success: Take oyster shells, and clean them with warm water. Put them into the fire for half an hour; at the end of that time take them out, and let them cool. When quite cold pound them fine, and take away any gray parts, as they are of no use. Put the powder into a crucible, in alternate layers, with flowers of sulphur. Put on the lid and cement with sand, made into a stiff paste with beer. When dry put into the fire and bake for an hour. Wait until quite cold before opening the lid. The product ought to be white. You must separate all gray parts, as they are not luminous. Make a sifter in the following manner: Take a jam-pot. Put a piece of very fine muslin very loosely across it; tie round with string. Put the powder into the top, and rake about with a bit of stick until only the coarse powder remains. Open the jam-pot and you will find a very fine powder. Mix into a thin paint with gum water, as two thin applications are better than one thick one. If these directions are carefully carried out, success will be the result

[Translated for the SCIENTIFIC AMERICAN from *Unsere zeit.*]

THE PRESENT CONDITION AND THE FUTURE TASK OF MODERN PALEONTOLOGY.

By CARL VOGT, Professor of Paleontology, Geneva, Switzerland.

WHEN not only in the natural sciences, but also in those branches of human knowledge which are apparently more remote from the exact sciences, the mighty waves can be felt which Darwin's powerful genius first set into motion, then we can scarcely be astonished that paleontology, or the science of petrifactions, from the armory of which Darwin himself has taken so many a weapon, is among the foremost of those branches of science which have experienced almost a complete revolution.

Therefore, I may be permitted to glance, in this paper, at the beings that lived in earlier times, and at the proper method of studying them at the present day, in a manner which is essentially different from the views previously held in that it tries to prove the relation between the types which have become extinct and the modern representatives of the organic world, which can be demonstrated by generation and descent, without claiming the intervention of a special power of creation which exists separate from the organisms.

From the ban of the church paleontology had already liberated itself when it first came into existence, but not so from the pressure of religious conceptions and the speculations of natural philosophy. Even our own times are still haunted by the ghosts of a belief (although these have become considerably pale) in revolutions and cataclysms, by which, after long periods of quiet and steady development, our globe was said to have been perfectly transformed. Mountain chains were raised up during such revolutions, continents sank, the bottom of the sea brought to the surface, and always after such periods of terror, the last among which was the deluge, by the fiat of a creator a new organic population of the globe, better and more beautiful than the previous one, but only connected with it by the unity of idea which pervades the fixed plan of creation and not by material bands, was called into life.

Such were the conceptions which were held even in recent times, and which are still sustained even in our day by some investigators. Yes, one could say that these ideas, though they are no longer defended with the same assurance and to the full extent as some years ago, nevertheless form, nowadays unwittingly, the basis of a great many investigations and scientific labors. They rest, indeed, upon observations which, for limited localities, prove to be perfectly correct, but are unsatisfactory, as soon as we try to extend their results over a larger field and through the whole series of the strata that are known to us.

In former times the science of petrifactions treated, chiefly of the nature of the petrifactions themselves and of their origin, without going into details. One defended the view that they were mere plays of nature, imperfect efforts of a creative power innate in the stones which had tried to imitate in mineral matter the products and forms of the organic world; another, on the contrary, derived all petrifactions, wherever they might be found, be it in the depths or in more superficial strata, from the deluge which had destroyed all living beings. It was, as we all know, customary in the good old times to go out from the general to the special, and speculation believed it had the duty of smoothing first the way upon which observation should limp after. Why should the science of petrifaction have been treated otherwise? Strict scientific observation did not obtain its rights before the end of the last and the commencement of the present century, when on the one side it began by comparing the petrified remains with similar parts of living organisms to try to discover their difference and conformity, and on the other side investigated the conditions of strata and drew conclusions from the dissimilarity of petrifactions which were found in the various strata.

Let us first consider this latter point of view, which was chiefly accepted by professional geologists for the further advancement of knowledge.

There could soon be no longer any doubt that in the different superimposed strata, of which the lower ones were the older and the upper ones the younger, different petrifactions were also contained which could be classified according to their exterior characteristics. Very soon it was discovered that many of these petrifactions were spread out over a large area and could be found at nearly every place where the same group of strata was recognized by other marks.

The deeper the ground was entered the more accurate the distinctions between the kindred species were established; the more exact the single and limited localities were investigated pace by pace, the more the conclusion was arrived at that each group of strata contained its peculiar petrifactions which were characteristic of it, and permitted the recognition of the strata where other marks were insufficient. Foremost among those facts which created the greatest sensation and gave to the above mentioned method of study an apparently indestructible basis, is the discovery of Alexandre Brogniart, the renowned fellow-laborer of Cuvier, who proved that the hard black rocks of the Diablerets in the Alps of the Canton Vaud in Switzerland contained the same petrifactions as the soft light colored limestones which in the neighborhood of Paris are used for building purposes. At that time it was still believed that the Alps, because the highest, were also the oldest mountain chain in Europe, and now suddenly by the investigation of the mighty ridges and tops of those mountains a fact was revealed which proved that they were deposited in the sea at the same time as that comparatively young limestone. Thus it came that the petrifactions could, as the Englishman Mantell expressed himself, be considered as "medals of the creation," *i. e.*, as objects which, like metals and coins, were buried at certain times into the ground, and now are brought to daylight and bear different marks which, so to speak, replace the date stamped upon a coin. Now it was believed that the relative age of a stratum and its place between the overlying and underlying strata could be precisely determined as soon as a greater or smaller number of petrifactions, being identical with species found in other places, had been discovered in that stratum. Equal petrifactions, equal strata, equal age, was the principle which governed the geology of the layers which were deposited by the water. The more it was found out that other marks by which layers could be identified were wanting, the more the identification by means of petrifaction became a law. That strata of very different mineralogical composition could contain fossils of the same kind, and that they, therefore, must be of the same age, has been seen in the case above mentioned of the stones of the Alps and the Paris basin, to which may be added many other examples; that stones of equal composition, as limestone and

sandstone, often contain very different kinds of petrifactions, was also known long ago. The old red sandstone which underlies the pit coal can in small pieces scarcely be discerned from the so-called "bunter sandstein" (colored sandstone), which is formed in the Vosges mountains and in the Schwarzwald (Germany), and which lies high above the coal formations and is separated from it by mighty systems of layers. Nevertheless, both kinds of sandstone, which, mineralogically, cannot be discerned, contain petrifactions which are so different that even an unscientific person could not mistake one kind for the other.

Just as often the relative stratification leaves us in the lurch. In such places, of course, where the layers are deposited in an undisturbed series, where *b* lies upon *a*, and *c* upon *b*, it is possible to determine by the stratification alone the relative age, the only age which geology can determine; in such places we can swear that *b* is younger than *a*, and *c* younger than *b*, and that these layers correspond to other layers which present the same sequence of stratification. But such localities are rare; at one place, at the time when *b* should have been deposited, the ground was lifted above the level of the water; *b*, therefore, was not deposited, and *c* rested immediately upon *a*; at another place, *b* had been deposited, but had been soon swept away again, so that in this case *c* lies also upon *a*. Mere comparison of stratification would, in such cases, which are a hundred times repeated, give a very inaccurate result, and from this confusion we can be saved only by comparison of the petrifactions.

It may be added that the geology of that time everywhere scented signs of great past revolutions. Each change in the stratification, just as each change of the fauna and of the flora, was said to have been produced by such a general disturbance of our earth. Where the traces of these revolutions could not be proved, the existence of them was, nevertheless, supposed to be certain; thus the general theory was at hand, according to which a great number of periods of creation was accepted, all of which were supposed to be introduced by a total renovation of the organic life on the earth and to be closed by a total destruction of it.

This system was not yet completed in its whole rigidity when already important defects were discovered. Systems of layers which in the one locality appeared to be distinctly separated, in another locality ran together, so that no separation could be established; well characterized species which were here limited to a certain group of layers, there reached far out of it, extending above and below. Alcide d'Orbigny, who, with extreme consistency, tried to uphold the distinctly separated periods of creation, even arrived at the conclusion that such long lived species were certainly destroyed at each revolution, but were recreated at the beginning of each following period of life. But with this curious idea the system itself fell together. The more one followed the facts, the more one came to the persuasion that no sharply cut off periods existed in the history of our earth, and that the commencement of a new period of life cannot be denoted even by a relative date any more than can a period in the history of men. The adoption of the views which are held in our day, and according to which the different floras and faunas which followed each other were not produced by sudden leaps but by gradual transitions, was assisted not only by these direct observations but also by many other circumstances.

As yet I have only spoken of the smaller groups of layers of which the petrifactions contained in them represent a comparatively small duration of time in the history of our earth, but there had been made a discrimination of greater epochs which were chiefly characterized by the appearance and disappearance of certain typical organic forms. The appearance of the placental mammals characterizes still to-day the tertiary period, while the disappearance of the *Cornu ammonis* denotes the end of the cretaceous period. If the effort was made to adapt the results gained in the animal kingdom to the vegetable kingdom, then an insoluble confusion was the result. The great periods which were marked by the appearance of new forms in the flora, such as the Dicotyledons, were in no way coincident with the epochs adopted for the fauna. Regarding the series of the cretaceous and tertiary formations, which are so complete, and which at the foot of the Rocky Mountains of North America occupy such an enormous space, the botanists accept a limit between the tertiary and cretaceous strata, which is perfectly different from that accepted by the zoologists, and each of the contending parties is correct as soon as we accept its point of view. How would it be possible, therefore, to bring these facts in accordance with sudden revolutions? In the vegetable kingdom the development went on uninterrupted, while in the animal kingdom it seemed to be suddenly cut off.

With the extension of geological investigations over the borders of Europe, there fell also many barriers. It was discovered that, already in the earlier epochs, the organic world was divided in more or less limited provinces, just as is to-day the case. Indeed, if he who accepts the grand principle of the medal theory, according to which equal organisms signify contemporary existence and unequal organisms a different age, were to employ this principle for our modern creation, then he would come to the very curious result that the present flora and fauna of Australia and South America belong to a different period of time than those of Europe. If we leave out of sight those plants and animals which are introduced by man, then there exist in those countries no organisms which are identical with those of Europe.

Meanwhile, as the weight of these objections against the separate periods of creation increased more and more, a perfect revolution of the geological views had taken place, especially through the labors of Lyell. The theory of the mighty revolutions was now replaced by that of the gradually and continually working evolution; the raising of the continents and of the mountain chains is to-day no longer considered as the result of sudden events, but is believed to have been brought about by movements which were effected by the summation of molecular forces. With the victory of these views which at present may well be proclaimed for the whole line, the single acts of creation were also overthrown and buried for ever.

We now stand at the turning point of the science of petrifactions, as far as it is employed, for the discrimination of the different groups of layers and the greater systems of strata. It is not so much the question to characterize the single layers by means of guiding shells in order to determine the place which these layers occupy in the series—that belongs, so to speak, to the A B C of science—as it is to ascertain by the study of the petrifactions themselves, and by the combination of geological facts, in what kind and manner the general changes have taken place, and by what causes they have been brought about.

First in rank have to be considered the conditions under which the strata containing the petrifactions have been deposited. The fresh water has different inhabitants from the sea; turf-moors consist of different plants than forests and meadows. The remains of land reptiles, mammals, land snails, etc., will be found in strata which were formed by standing waters, seas, morasses, rivers, and creeks; they will even be found in layers which were deposited in bays and in the mouths of rivers, and will there appear to be more or less mixed with those inhabitants of the seashore which live in such waters and estuaries. Crocodiles and other reptiles are just as fond of the lagoons which are connected with the open sea as they are of the inland seas, and many a museum contains bones of such crocodiles of the Jurassic period upon which oysters have settled. On the other side, sea fishes, such as soles and sharks, very often enter far into the mouths of rivers and come so into deposits, which, by the leaves, land snails, and river fishes found in them, indicate that they have been formed in fresh water. One of the most striking examples of this kind furnishes the lithographic stones of Solenhofen and its surroundings in Bavaria. It is obvious that this kind of slate was formed from the very fine slime, or mud of lime, which was deposited upon the bottom of a fjord, which cut deep into the country, and was surrounded by a forest. If the animals happened to come into this slime when the surrounding conditions were favorable, then the slate shows a marvelous preservation of the impression, even of the softer parts. Gelatinous medusæ (sea nettles) and jelly-fishes, which, thrown upon the sand, are dissolved into formless slime in a few hours, are, in their impressions, just as well preserved as the fine branches of the seaweed and the algæ, which grew on the bottom of the water, and the hairs which line the feelers and the legs of the crabs are just as plainly distinguishable as the contours of the soft parts of the cuttle-fish. Among the thousands of the inhabitants of the sea which are found in these strata there are also detected remains of land animals not less well preserved. Libellulæ, dragon-flies, and butterflies show the lattice work of their wings with surprising distinctness, and the archeopteryx, that being which forms the transition from the reptiles to the animals, and which has also been called "Urvogel" (Primitive bird), permits us to recognize the finest branches of its wing feathers and of its down. All these are just as doubtless land animals as the flying reptiles (*Pterodactylus*), which are found in the same calcareous slate. Wherefrom comes this curious mixture, if it is not due to the circumstance that these flying animals tried to leap over the fjord, and found their death by falling into the water, where, sinking into the ground, they were at once surrounded by the slime of lime?

While here the conclusions to be drawn are, so to speak, as plain as day, not so easily can they be found, if the conditions of the deposits of the sea have to be explored. Our explorations of the bottom of the sea are still in their infancy, although in recent times, by the labors of the English and the Americans, some important facts have been revealed. My friend Greszly was the first who, after exploring his native Jura Mountains, in Western Switzerland, drew the attention to the extraordinary influence which the constitution of the bottom of the sea has upon the distribution of its inhabitants. The slimy bottom harbors settlers which are altogether different from the fauna and flora which grow upon the rocky ground. The coral reef has different inhabitants on its outside, where the waves break against the wall executed by the polyps, than on its inside, in the shallow lagoon, which offers a welcome protection to the thin-shelled animals which might easily be broken against the rocks. Greszly summed up the conditions of existence which are given by the nature of the bottom of the sea, under the name of "facies," which name has been preserved in science. This or that shell, he says, is found in the slime facies of the Upper Jura; that snail belongs to the coral facies, etc., and, in using this term, he united in one word the result of the tiresome comparative studies which he had made regarding the conditions of the existence of sea animals living at the present time, and which had occupied a great number of years.

Here it is the place to mention the important influence which the explorations of the deep sea had upon the paleontological views. While previously the exceptional conditions which, according to Forbes, exist in the Ægean Sea, were elevated to a general rule, and while it was believed that below a certain comparatively small depth of the sea there was no organic life, now the necessity was seen for acknowledging that animals of different species are formed, even in the greatest depth, and that therefore all the groups of layers which, because no petrifactions were found in them, were said to have been deposited in the greatest depth, could not be identified as to their origin by this characteristic alone. But these investigations showed still more. They proved that in great depths, which, even in the seas of the torrid zone, have a nearly uniform and comparatively low temperature, a great uniformity of organisms also prevailed, and that certain types can claim a diffusion over the whole earth. This also partially explained the unusually large diffusion of certain related types in the older deposits. They were evidently animals from the lowest depths, which, following the conditions existing in those regions, spread out everywhere where those conditions could be found, the most important of which is certainly a temperature which is not subjected to the changes of the seasons.

It was especially these investigations of the deep that gave to the old theory of distinctly separated epochs their final death blow. How was it possible to still maintain this theory in opposition to the fact that, upon the broad bottom of the sea which separates Europe from America, and which, on account of the use that has been made of it, is called the telegraph plateau, calcareous deposits are still formed to-day by the same lower animals that worked in that direction in the cretaceous period? No microscopist has been able to tell whether the specimens of those infinitely small round dishes which belong to animals of the lowest class, viz., foraminifera, and which are entered into the registers of science under the name of "globigerina," were taken from the slime which covers the bottom of the sea, or from the chalk cliffs on the French and English coast. Those little animals which are deposited in enormous quantities in depths of 10,000 feet have therefore lived during the whole cretaceous and tertiary period; they have lived during the formation of the deposits of the nummulite stone of the "grobkalk" and of the "molasse," each of which has a thickness of nearly 3,300 feet; they have lived to see the formation of the latest elevations of the Pyrenees, of the Alps, and of the Carpathian Mountains, not to speak of the Himalaya and the Caucasus; and just these elevations have, according to the old theory, been formed during the most general revolutions in the history of our earth.

The "globigerina" stand not alone. In the higher classes of animals, also, similar phenomena may be seen. The beautiful group of the stone-lilies encrinites), which in the oldest strata developed in such manifold forms of appearance, seemed nearly to have died out in our modern creation. The net brought from the depths a great number of the most interesting forms of these animals which belong to the class of the echinoderms, and to-day we consider the forest of crinoids as a phenomenon which is just as normal as the slime of the globigerina. Many animals of the deep sea have adapted themselves to the high pressure, the temperature, and the darkness that there prevail, in such a manner that they cannot live on higher levels; others, on the contrary, are able to endure a change of the level, and others again, which are accustomed to live in higher levels, cannot adapt themselves to the conditions of the deep sea. These facts explain why, in certain localities in the older strata, certain species survive while others have disappeared. Greater or lesser oscillations of the level, produced by secular raisings and sinkings of the level, have produced results which at present can be explained in a very simple way, while before they were attributed to the immediate influence of a creative power.

A flexible coral, *Lophelia prolifera*, grows still to-day in the great depths near the coasts of Northern Norway, where I myself found it. In the bay of Christiania there are places where the corals growing out of the rocky ground can be seen nearly immediately below the surface. But all these corals are dead; they are, as Sars has proved, silent witnesses of the slow raising of Norway, which took place after the ice period and brought the corals to levels where they could no longer live. On the other side, according to investigations made in the depths of fresh-water seas, it can scarcely longer be doubted that all animals now living in the greatest depths were originally animals which lived near the shore, and which, sinking more and more into the depths, adapted themselves to the conditions which there prevail.

Before this time the bottom of the sea was paleontologically considered to be of tiresome uniformity, where everywhere the same kind of petrifactions occurred. According to the new investigations we must become familiar with the thought that, in layers which were deposited in great depths upon the bottom of the sea, nevertheless a great variety of minerals exists, which inclose organisms of different species.

Paleontology has thus placed before it perfectly new tasks. The bottom is thus removed from under the ground principle, which we mentioned above, and according to which different mineralogical character and different fossil inclosures indicate also a different age of the deposit. Yes, if we could everywhere follow out the continuation of the layers, and if we could show how on its borders matters and organisms which were carried thither by two different currents of the sea have been gradually become mixed, then it would be easy to overcome these difficulties; but mostly this is impossible, and the following out of the stratum is only in the rarest cases possible, because the covering by vegetation or by other strata, or the washing away and destruction of the stratum, offers obstacles to the investigation of any great distances. We must now openly acknowledge that the previous determinations of the equal age of many strata which were heretofore considered to be perfectly established may to-day be doubted with full right, and that it will take hard labor, assisted by great ingenuity, to remove these doubts or to corroborate the old theories. I know very well that most geologists passionately oppose the conclusions drawn from the investigations of the depths, and deny that they have any value for the criticism of their theories; but that does not do away with the fact that these conclusions will have to be considered sooner or later, and it is one of the chief tasks of the future to revise the principles which form the basis for the application of paleontology to the order of strata in its full extent. With the investigations of the deep a new field of paleontological labor is connected. The sea animals evidently migrate in the direction of that constant current which prevails in the zone of the deep where they usually live. With the polar current which flows from north to south in the broad basin of the ocean west from the Hebrides, the animals which live on the surface of the ocean near Spitzbergen and Janmayen migrate towards the south; with the opposite equatorial or gulf stream the southern species migrate towards the north along the English and Norwegian coasts. Whether these migrations are passive or active, whether they are executed by the young larvæ or by the matured animals, is perfectly indifferent as far as regards the result. It is sufficient to keep in sight the fact that all animals that live in free water, even if during the greatest part of their existence they are fixed to the ground, nevertheless during a certain epoch of their life enjoy the faculty of free locomotion and use this epoch for migrations. Yes, we may boldly assert that all organisms, plants as well as animals, so long as we consider them as a species and not as individuals, in a certain state, migrate and are obliged to migrate; that the locomotion, may it be extended over greater or lesser distances, is a fundamental law for the organic world, and that each species would finally circummigrate the globe if no obstacles were imposed and if a sufficient time were allowed for the purpose. Those plants which are fixed to the bottom migrate by means of their seeds and germs, which are carried away by currents of air, insects, and birds; the animals by their organs of motion, or by the currents of water in the air. The migrations of birds through the air and of fishes and whales through the water, which are periodically repeated at certain times of the year, are only the extreme expressions of these migrations which are executed by all organisms.

But these migrations have, as I have tried to prove some time ago in another place, an extraordinary bearing on paleontology. They must in earlier epochs have taken place in a similar way as to-day, and they must have transformed the physiognomy of certain deposits the more, as they were executed in a very slow and steady manner. The traveling over each distance takes time, and this time will be the greater, as regards actively migrating animals, the less their faculty of motion, and as regards passively migrating organisms, the less the chances by which they are carried away.

In what relations, now, do these migrations stand to the organic contents of the strata? Are strata which are far distant from each other, and which contain the same animals and plants, of the same age? The geological periods in which the single groups of strata were deposited can certainly not be measured by centuries, but, nevertheless, there are sufficient reasons for making the assumption probable that migrations of this kind have extended over several geological periods. Barrande has already long since drawn our attention to the fact that in the siluric strata of Bohemia, which are among the oldest deposits known to us, there are so-called colonies which he could not explain in any other manner except in assuming that the inhabitants of the neigh-

boring siluric basin of the Fichtel Mountains, in consequence of the breaking through of the otherwise so strictly separated waters, had been carried to Bohemia, and, after settling down there for a certain time, had become extinct.

For many land animals there exist similar suppositions. There are a great number of deposits of the middle tertiary period (miocene period) in Europe and in Asia, of which may most easily be compared the Sivalik hills at the foot of the Himalaya in East India, those of Pikermi at the Pentelikon Mountain in Greece, and those of Sansans at the foot of the Pyrenees. All of these deposits contain their peculiar remains, as for example, Sivalik the gigantic Sivatherium, Pikermi the not less mighty Helladotherium, both belonging to the family of the ruminants, and Sansans the remains of a monkey Dryopithecus, which has such great similarity to man. All those deposits contain at the same time types of great conformity, which, if they do not belong to the species, belong at least to the genus: rhinoceroses, hogs, mastodons, carnivorous animals, antelopes, etc. Besides these types which correspond to each other, there are in the Sivalik hills elephants, hippopotami, and oxen, which in Pikermi and Sansans are never found, but which have been in Europe discovered in great number in the deposits of the younger period, *i. e.*, of the pliocene period. There are scarcely any pliocene layers in Europe where these types cannot be found, while in no European miocene strata can any trace of them be detected. Must we not then imagine that oxen, elephants, and hippopotami from Eastern India, where they first appeared, migrated toward the West and arrived only after a slow and long migration, which lasted perhaps thousands of years, in the pliocene period in Europe?

There are many more similar examples. These migrations have perhaps been misused in later times, because geologists have based their arguments on the unproven fact, viz., that each species cannot have been developed more than once in the same place. This view led quite naturally to the perfectly consequent conclusion that types which have a widely extended area of expansion had also executed great migrations, and that such types which, for example, were found during the miocene period in America and during the pliocene period in Europe, had migrated from one continent to the other. But this misuse does not prevent, within certain limits, such as seas, high mountain chains, deserts, etc., the supposition of these migrations from being perfectly correct and deserving of our consideration. But here, where the deposits which inclose fossil remains are concerned, the close interchange between the single geological branches becomes also manifest. He who takes these migrations for granted, has also to prove that they were possible, as far as regards the distribution of continents, seas, mountain chains, large rivers, etc., and for such proof the combination of, we may well say, all geological facts, which have ever been brought to daylight is necessary. I will come back later upon these migrations and local movements, for, certainly, they could not exist without producing a certain reaction upon the types themselves, and an adaptation of these types to the different conditions of life through which the migrators had to pass. But the study of these influences and of their effects belongs to another branch of paleontology, in speaking of which, later on, I will consider it. But what I have said above will already be sufficient for the attentive reader to draw the conclusion that the point of view from which the geological part of paleontology is and has to be treated at the present time is perfectly different from that which formed the basis of these studies in earlier times.

Count Gaston de Saporta, one of the most eminent investigators in the field of plants, in the introduction of his splendid work which has just appeared, and which is entitled "The Plant-World before the Appearance of Man" (Le Monde des Plantes avant l'Apparition de l'Homme), says: "For a long time it was thought sufficient to describe the organic beings only as individuals, considering their mutual relation only in so far as it offered a convenient means for classification. But after so many discoveries, which have enlarged the field of paleontology so greatly, it seemed imperative to me to make every effort in order to detect the true meaning of the general laws which govern the development of the organic world.

"I wanted, therefore, not only to describe the older vegetable periods and the peculiar forms which characterized them, but I also desired to treat those questions which are connected with the investigation of phenomena so complicated and manifold, and to illustrate the theory which tries to explain them. Although resolved not to lose myself in sterile discussions, or to look for solutions which at present would only lead to vain fancies, I nevertheless thought it my duty to exhibit all the difficulties with which the study of the fossils is connected in their reality to the mind of the investigator who endeavors to look beyond exterior appearance into the depths of things."

These words may well be sufficient to indicate the task which paleontology has to accomplish. Our age does not disdain the splendid works which are the fruits of the admirable ingenuity and of the indefatigable labor by which Cuvier has erected the ground walls of comparative paleontology, and which were further completed by his successors, among which R. Owen deserves the first place; but it goes farther than these predecessors, and guided by established facts and by the evolution theory founded by Darwin, it endeavors to throw light upon the darkness which surrounds the conditions of relation and descent.

(To be continued.)

PROPHECY OF THE WEATHER.

By ISAAC P. NOYES, Washington, D. C.

THE weather has ever been a favorite theme for the prophets, and most miserably have they failed. All are familiar with the prophecies or statements of our almanac makers. For years they have pretended to foretell the weather for months in advance.

The statements of the old almanac makers, though "gospel truth" to the many, were not regarded as wisdom by the few who were more advanced in intellectual culture, yet even those of the highest culture could simply say "they did not believe;" no positive evidence had yet developed by which they could successfully controvert what their intellects could not accept. They must await future developments and see what they would bring forth.

In 1870 they brought forth the United States Signal Service, whereby we were no longer confined to the accumulation of a few isolated facts gathered by men having no facilities for immediate communication with each other, or any means of conveying intelligence to one central head where it could be digested and made to serve the world as kindred facts in other departments have done.

It was not even possible for the Signal Service to grasp the full idea at once; time was needed to advance the practical work necessary for so great an undertaking, and as facts were accumulated, they suggested new fields for the intellect to revel in, until now we have a very complete system, though not perfect as yet, for time is still necessary to complete and to suggest other steps in the line of this advancing science.

The weather map has proved beyond controversy that the area of low barometer is the center and motive power of the storm, and that this area of low barometer travels, as heretofore stated, in an easterly direction, and that back of this power of low barometer lies the generating heat force of the sun, the creator of this power. The sun is our great physical first cause in this as in other things connected with and essential to our well being on this earth.

The negative part of the weather system is the area of high barometer, which plays quite as important a part in the weather of our globe as the area of low barometer itself. The details and influence of high barometer will be deferred for some future paper, simply remarking here that it is an important power and is ever on the move and in the same general direction as the area of low barometer, and that we cannot have the one without the other—that the area of high barometer is as essential and natural in the lighter body air as the hill or mountain in the physical contour of our earth.

It is not pleasant to controvert such a venerable notion as that the moon affects the weather, and that by studying its various "quarters" and conditions, we may be able to prophecy the weather months in advance. The moon, it must be remembered, is continually on the move, and ever progressing with the earth and the while moving around it. It therefore must necessarily, and does in turn, shine on all parts of the earth. Wherever the sun shines the moon shines also. The sun being a powerful heating body, generates the conditions we term low barometer. The moon, being a mere reflector of light, has no such power—at least its heat power is infinitesimal, and therefore has no power to produce or affect the area of low barometer. But it is often claimed that it has power over the clouds to collect or disperse them, as the case may be. On the same night with the same moon, new, first quarter, half, full, last quarter or old, the same moon is shining over territories where there is all sorts of weather from hot to cold, and from clear, cloudless skies to extents of territories covered with the most dense snow or rain-producing clouds. In one place it may be clear, bright moonlight, in another not a ray of light to be seen even with a full moon. Then these places may be and are distributed over the earth at intervals of from 500 to 1,000 miles, and sometimes more. This being the actual condition of things, it seems most absurd to claim or believe at this day that the moon at all affects our weather, or that it may be relied upon as a basis on which to found prophecies of the weather. When the new moon is upright so that its two ends or horns are level with each other, it is claimed that throughout this moon we will have little or no rain, because the moon holds its water. Then when the crescent tips a little, one side being higher than the other, according to the universal idea, we will have plenty of rain during that moon. As though the rain which waters our earth must be held in this little basin up in the sky. It must be remembered that the moon is 240,000 miles away from our earth, and at the best calculation our atmosphere is not more than forty-five miles high, and more than this, that the clouds from whence comes our rain are not over two or three miles high, and often much less, probably less even than a mile high. Our rain comes from the clouds that are temporarily suspended in the air generated through the heat force of the sun from the waters of the earth.

The sun is ever forming these clouds. The power of the moon in this particular is not worth considering even for a moment—might as well claim that the moon causes plants to grow, and is an agent for the generation and maintenance of life on this globe. As it rotates about the earth it happens that it goes through certain phases which we term new moon, quarter, full, etc., and that at times the horns of the new moon will be level with each other and at other times not—all depending, as any one familiar with astronomy will know, on the relative positions of the sun, earth, and moon. The sun will always shine on that side of the moon that faces the sun. This is a most natural effect and needs no proof. Relatively to the earth the moon must change, for the simple reason that these three bodies are ever changing their relation to each other, and this readily accounts for the different appearances of what we call the "new moon," the light of the sun shining on it, relatively to us, underneath, at other times a little to one side. That these merely accidental changes of the moon that have no significance as a motive power, positive or negative, that they should be a power to affect the conditions that produce or prevent rain that comes, and can only come by the generating force or heat of the sun, is most absurd, or that it should have any power over the motion of the clouds, which are concentrated or dispersed only by that power generated by the sun which we term "low barometer." The prophecy of the weather based upon any such ideas as that the moon has any influence in producing such results, is most absurd and cannot be maintained by facts or the least show of reason. We may have evenings where the sky over our particular locality becomes clouded when the moon is visible, or it may be cloudy and after awhile the clouds pass away, but not through any agency of the moon. If the moon had any such power as this, it would produce the same results every time, but we see that it does not, but rather with all sorts of moons we have all sorts of weather and changes which may readily be traced to a far more reasonable cause—that of the relative conditions of low and high barometer as effected by the great source of heat and light—the sun.

Another source of prophecy of the weather is something which belongs rather to a season than to any extended time of years—a sort of sub-prophecy depending upon a prophecy of cold winter and warm summer, especially at the poles, is that of cold in summer developed from melting icebergs as they flow down from the Arctic seas. This summer of 1880 there are a remarkable number of these icebergs. So the iceberg prophets are prophesying cold weather, especially off the Atlantic coasts.

When it becomes better understood that the heat of certain localities depends upon the concentrated power of the sun, making what we term the area of low barometer, and that this concentration is ever on the move, sometimes on a lower line of latitude the whole year through—when this beautiful law of nature is understood, it will be seen that the melting or non-melting of icebergs out in the Atlantic ocean will have little or no effect upon our temperature, not one-tenth part as much as the melting of the ice in our ice carts as they pass along the streets, or the melting of the ice in the refrigerators and water coolers of our houses.

Although the sun shines more directly over the equator than over the poles, and it is therefore warmer at the equator than at the poles, still the heat of the sun is not wholly concentrated there, and it is oftentimes warmer in the temperate zones than in the tropics, as discussed in a former paper, "Evidence from the Weather Map of 1879."

The melting of icebergs cools the immediate surrounding water and atmosphere, but its influence, like the melting of the ice in our ice houses, ice carts, refrigerators, or water coolers, is purely local.

In this connection the idea suggests itself that we make a better study of icebergs than we have heretofore done, and that one or more of our idle navy vessels be authorized to follow them, keeping as near them as safety will permit, and study them day by day, and trace them up until the largest berg disappears under the heat of southern latitudes.

Then there is another, though fortunately a smaller class, who make some pretensions to scientific wisdom, who have notions that the weather of our planet must be more or less affected by the relative position of our earth and her sister planets in the universe. For this year, these prophets have predicted all sorts of commotions in the elements because some four of the principal planets of our system come together nearer to the sun than for some eighteen hundred years or more. Indeed they are already out with their extravagant claims that (up to July) we have already had the fulfillment of the prophecy.

Now, the weather of this year has not been remarkable for its peculiarity thus far. We have had some severe storms, but what season do we not have them? They occur more or less frequently every year. This year, thus far (July), has not been greatly different from the average year. But when this class of prophets have prophesied, like Jonah, they want their prophecies fulfilled even though it bring great distress upon the nations. They do not like the mortification of being false prophets, or to see their scientific pretensions laughed at by the world.

Probably the most remarkable sensation as a weather prophet at present is Mr. Henry G. Vennor, of Montreal. The name of this gentleman has been very conspicuous in the papers the past season as a weather prophet. Many people have faith in him and verily believe that he is reliable, and are willing to swear by him and contend that he predicted this and that storm, or spell of hot or cold weather.

When men claim to be prophets we want them to come out with plain and unequivocal statements. We want no "if" or "and," or general statements of uncertain sound, but the plain statement in black and white, just what will and will not occur.

According to the St. Louis *Republican*, in a letter dated Montreal, May 18, 1880, he says: "I believe that June will be an intensely hot month, and probably the first of June will be fall-like, with frost again. July will be a terrible month for storms, with terms of intense heat, but another fall-like relapse with frosts will, in all likelihood, occur a few days before the twentieth. I fear the storms of thunder and hail will be of unusual severity during July. I must claim the verification of my prediction relative to a cold wave, with frosts, over a large portion of the United States between the tenth and fifteenth of May. The relapse toward the close of the present month (May) will be more severe than that just past."

This is probably a fair sample of Mr. Vennor's predictions. We see that they are very general and non-committal as to dates and localities.

Mr. Vennor's first statement in this short article is that "June will be an intensely hot month." Where will it be hot—in Canada, or north or south of Mason and Dixon's line? It might be very hot in Pennsylvania or even in New York State, and yet very cold in Montreal. Over what territory must it be hot or cold to fulfill Mr. Vennor's predictions—in the Atlantic States, out West, or at the North or South? He claims the verification of predictions relative to a cold wave over the United States between the tenth and fifteenth of May.

As to the month of June, it was not unlike June weather in general, unless perhaps a little colder, as a whole. In the vicinity of Washington it was rather a cool month, though we had a very few hot days, still not as hot on a whole for the season as was the month of May. The greater part of May in this vicinity was very hot and oppressive, and that too for a very good reason—and it is never hot or cold relatively to the season, without this good reason.

May tenth and eleventh it was very warm here. On the eleventh, about 4:30 P.M., we (in Washington) had a summer shower with thunder and lightning, which lasted about an hour and then became cooler, as it generally does, though not always after such a storm. From the twelfth to the eighteenth of May it was cool and pleasant, very seasonable weather for the time of the year. On the fourteenth of May it might have been intensely cold throughout the United States, east of the Mississippi, but for a rather unusual relative location of the area of high barometer. On the fourteenth of May *low* was on a line with the south end of Florida, while *high* was to the north of Washington, thereby preventing Mr. Vennor's prediction falling true in force, or at least ameliorating it much. The latter part of May was extremely hot notwithstanding Mr. V's. prediction that we then would have a severe relapse.

July, Mr. Vennor says, will be intensely hot with terrible storms with another fall-like relapse. Now we all know that July is very apt to be hot, and therefore to be accompanied with severe storms, and it is not an unusual occurrence to have a cold spell or two during the summer, and that we are as liable to have it in July as in June or August.

In all these statements Mr. Vennor is no nearer, and gets as far from the mark as any other man who will study the Smithsonian or other reliable reports of the weather of the United States from year to year and venture a guess in accordance therewith. Fortunately for such prophets, the people, and even the people of high mental rank, are still quite ignorant of this weather question. It is a new subject. Many may disbelieve, but at the same time they are unable to refute, so are very charitable to pretensions of this kind, coming from what they think or regard as commendable authority.

These changes of weather which Mr. Vennor speaks of never occur without a good and sufficient cause—a cause that may readily be understood by any intelligent person who will simply read the weather map—for it is there daily recorded in legible characters that never deceive. For example, it cannot possibly be hot in the northern part of the United States or Canada, unless there is an area of low barometer in that locality. It cannot be cold throughout the United States unless the area of low barometer is on a low line of latitude. There is an endless variety of changes which the movements of low and high barometer may make—more endless than the strains that could be played upon the "harp of a thousand strings." Sometimes by the peculiar location of the area of low barometer it may be warmer in the extreme north-eastern part of the United States than

in Virginia. For example, let the area of low barometer be located off on the Atlantic Ocean and in the immediate vicinity of Calais, Me., as it was some two or three years ago this spring. Being on a high line of latitude, it caused the warm winds from the south to concentrate there, while it being so far to the east of Washington, and reaching down into the ocean, caused a severe west wind slightly to the north of west which made Washington one of, if not the coldest (recorded) place in the United States, and much colder than Calais, Me., notwithstanding the fact of lower latitude.

Now when a cause is so well known, how much better would it be for these weather prophets to say that on such a date of such a month the area of low barometer will be in such and such a locality—then those who know what ought to follow—what would be the result of such a location of *low*, will know just what to expect. We will know whether it is to be cold or hot, in New England and the North-east generally or in Kansas and Missouri and the North-west. If these prophets will only tell us where *low* will be they will far surpass their present prophecies, and the world, at least the intelligent world, will truly wonder at their knowledge of the works and ways of the great mysteries of nature. But until they can do this they had better not attempt any more of their present "prophecies," which are merely guesses which may be equaled by any number of persons who will study well the compiled weather reports of the past years and venture guesses in accordance therewith. Prophets should be men of superior and not inferior knowledge in the department in which they propose to prophecy. For such a course will only make them contemptible in the eyes of the world, when it comes to fully understand the cause that affects these matters.

In reading these comments on the prophecy of the weather, it may be asked if there is any method by which we may know or prophecy the weather for any great period in advance. For one I do not believe there is any such method, for the reason that these changes depend, as repeated over and over again in these papers, that all depends upon the location of low and high barometer, and that these relations are ever changing, and the changes seem to be an endless surprise that cannot, so far as we know at present, be determined upon, even from one change to another, much less of changes that may follow each other, weeks and months in advance. Though if any law in this movement of low and high barometer is ever discovered it will only be by the careful study of the weather as recorded on the weather map.

This may sometimes be the case, but the Signal Office has advanced in its line of indications until they have made a record for a year of ninety-five per cent. in accuracy, and this must be acknowledged as not far from perfection. Why not have the indications been right every time? Let one become familiar with this subject and he will readily see *why*.

There are many reasons why. There are many people of exacting nature in the world, who always want positive statements that such and such *will be* or *will not be* the case, and their natures cannot conceive any circumstances but what the human mind can control; and when "circumstances" is mentioned to them, they have no place for the word in their lexicons, and with Napoleon I. when in success, they exclaim, "I make circumstances;" by and by a Waterloo comes, and they see, perhaps when too late, that there are circumstances which even the strongest man cannot control. If in the affairs of men there are "circumstances" beyond the control of these strong men, much more are there circumstances in nature that man must abide by. Nature is endless in her varieties, and man is powerless to prevent or at all times even to foretell her exact course. Probably nothing better illustrates this than to pour some water down a slightly inclined plane and note its course. We know that water will run down hill, but it does not take what appears to be the most direct course. We know and can readily predict that it will take, if left to itself, a certain general course, but when the practical reality takes place, we not only discover that it takes a course of its own, but that it passes over certain lines and circumvents spots, even in so small a surface as a few yards in length, that it was and would be impossible for human knowledge to specify or indicate beforehand. This being the case in nature when confined to a few yards square, what must be the effect of an area of low barometer passing over variable territory of more than a hundred miles square?

The Signal Office can tell the course of all regular storms, but occasionally there happens an irregular change, which is analogous to this running of water down hill, as seen in the course of almost every river, large or small, in the world.

In conclusion, I repeat there is no other reliable process than that of the Signal Service system whereby we may foretell the weather. All other known systems, if I may so designate or honor them, whether founded on the conditions of the moon, the habits of animals, the relation of the other planets to the planet on which we live, or the guesswork founded or unfounded on the weather of previous years—all these I hereby pronounce the merest nonsense, if not something worse—and that all these things are unworthy of any man who makes any pretense to scientific knowledge or claims any standing in advanced society.—*Kansas City Review.*

OBSERVATIONS REGARDING FALLS OF METEORIC DUST IN ITALY.

PROFESSOR PIETRO LANCETTA, of Modica, Italy, has published, in the *Rivista Scientifico-Industriale*, the following *resumé* of observations regarding falls of meteoric dust in Italy between 1876 and April, 1880:

The phenomena of showers of meteoric dust are perhaps the most common that can be registered in Italian meteorology. Indeed, if one were to take account of all the observations of Professor Saverio Clofalo, the distinguished collector of meteoric powders at Termini Imerese, of those of Mr. Giuliano, in Syracuse, director of the observatory in that city, and of the Meteorological Central Station of the Province of Syracuse, and of those made by myself and by my predecessors in Modica, one might say that this phenomenon occurs in every month of the year.

In Syracuse and Modica dust falls were observed in the months of March, April, May, June, November, January, and February, and in Termini Imerese they were observed also in the months of July, August, September, and October. The months, however, in which the dust falls most frequently and in greatest abundance, are March, April, May, but especially the first.

These phenomena may then be specially observed during the intervals of calm. The aspect which the sky presents during these phenomena is not devoid of interest.

On the appearance of the dust a sort of nebula extends across the sky, condensing little by little and obscuring the sun; it has a dark misty reddish lead color, and seems to veil the highest localities and sometimes to totally cover them.

The precursory signs of the phenomena are generally a great lowering of the barometer, a rising of the thermometer, and the blowing of two winds, a lower one commencing from the east and a higher one from the west, which oppose each other with a greater or lesser force until they both leave the field clear for the current of the sirocco.

The powder falls during the predominance of the sirocco, often announced by lightning and thunder, and accompanied by single drops of water and by sudden rain showers, sometimes even by hail. Finally the west wind appears, again strives for a longer or shorter time with the sirocco, disperses the nebula and the clouds, and at last triumphantly reestablishes serenity.

The atmospheric conditions during the fall of meteoric dust are the following:

(*a*) The barometer continues to fall.

(*b*) The thermometer continues to rise.

(*c*) Usually the air is full of vapor and indicates a great tension.

(*d*) Generally clouds of a reddish gray color swim in the air and dissolve in misty rain.

(*e*) The dust falls either with the rain or without rain after the air has been for some time filled with dry mist.

The meteoric dust which falls in this province are very light and are of a pale red color, analogous to that of brick powder. Sometimes their color is pure white or ash-gray; and, therefore, very much resembles the localities where they are found, especially the colors of the street. If these meteoric powders are put into water they give a slight acid reaction, make it turbid, and remain, if the water is stirred up, for some time suspended in it. Their specific weight cannot, therefore, be much greater than that of the water.

If these powders are placed under the microscope it is discovered that they contain diatomaceæ similar to those described by Ehrenberg and by Silvestri* and many other organic forms and fibers like those of algæ, etc. According to the observations of Professor Silvestri these meteoric powders have one very peculiar property, viz.: if brought under the action of a magnet it becomes evident that they all contain grains of native, or as it is usually called, meteoric iron; these grains vary in size from 0·01 to 1·10 millimeter, and have a perfectly irregular or else a round shape, as if they had undergone a fusion.† Some dust which fell on the 15th of April, in Autin, in Southern France, was examined by Professor Marie Davy, the director of the Central Observatory for Meteorological Physics in Paris, and bore essentially the same character as the powders which fell in Modica, the only difference being the color, which was of a little deeper red.

During the dust fall the air is heavy, respiration is difficult, and every one feels gloomy and oppressed. Whenever the dust falls with little or no rain, the blossoms and leaves of plants are withered, and the grain in the fields is very often damaged to such an amount that the whole harvest is destroyed. From these facts it is evident that Sicily is situated in a zone which is often visited by atmospheric currents which carry along substances derived not only from terrestrial surfaces but also from inter-planetary space, and it seems that just that province of Sicily in which Modica is situated is best adapted for the study of these important phenomena, which can there be observed nearly every month, and which may throw some light upon the causes of periodical winds and storms and of atmospheric currents in general.

Professor Arturo Stoppani seems, from a letter dated June 20, 1880, to have well recognized the importance which this investigation of the powder rains has for science. He says: "I am quite sure that the meteoric powders (cosmic or telluric, no matter which) are to the atmosphere what the fossils are to our globe, and that in time treatises will be written on meteorological paleontology."

With regard to the phenomena just described, another Italian scientist, Professor Emilo Piazzoli, writes: "In *Comptes Rendus*, t. xc., p. 1508, Professor Tacchini calls to mind that in the *Comptes Rendus* of the 17th of March, 1879, he has made mention of some ferruginous particles which were discovered in a powder-rain which fell at Palermo, Termini, and Naples during a cyclone on the 24th of February, 1879.

He has recently, together with Professor Maccagno, examined the powders which fell at Palermo, Modica, Termini, Girgenti, and Rome, and found them to contain the same globular iron particles; from this fact he draws the conclusion that meteoric iron always forms a part of the dust which is carried along by the sirocco and falls in Italy, especially in Sicily. Sand collected in the Sahara has shown under the microscope globules perfectly similar to those found in the powder of the sirocco; therefore, it seems evident that the powders of the sirocco in Italy are identical with the African sand. It cannot yet be said with certainty, however, whether the iron contained in the powder is of terrestrial or of cosmical origin, but it seems to be beyond question that the sand rains in Italy are purely terrestrial phenomena due to the cyclones which carry the sand over from the desert."

CARBOLIZED CAMPHOR IN DIPHTHERIA.

M. PERATÉ has, according to the *Bulletin de Thérapeutique*, July 15, 1880, for the last two years used carbolized camphor for the treatment of diphtheria. He paints the surface with a pencil dipped in the following mixture: Carbolic acid, 9 grammes; camphor, 25 grammes; alcohol, 1 gramme, diluted with equal parts of the oil of sweet almonds. The paintings are made every two hours in the day, and every three hours in the evening; then, after some days, they are divided by periods of three, four, or five hours, according to the improvement of the patient. These paintings are made over the whole extent of the false membranes, and with troublesome children the pencil is plunged as deeply as possible to the bottom of the throat, being of course, previously drained. The mixture has an extremely disagreeable taste, to which, however, the patient soon becomes accustomed. M. Peraté has been very successful with this plan of treatment.

* Ricerche chimico-micrografiche sopra le piogge rosse e le polvere meteoriche della Sicilia in occaisone di grande burrasche, del Prof. *Orazio Silvestri*, Catania. Tipografia di C. Galatolo nel R. Ospizio di Beneficenza, 1877.

† In our observatory (Modica) we have two microscopical preparations made by the above-named Professor O. Silvestri, the one containing meteoric iron taken from atmospheric powder which fell in Catania on the 29th and 30th of March of this year, and the other containing meteoric iron which was contained in a powder rain which fell in Modica on the 30th of March of this same year. This latter powder is of a decided yellowish-red brick color, and looked at in the sunlight presents numerous white glittering points, which, under the microscope, seem to be crystals of mica or of quartz.

HYGIENIC SCREENS.

MR. WENTWORTH SCOTT, says the *British Medical Journal*, recommends the employment of slag wool or silicate cotton, as a convenient disinfectant or odorizing medium. By impregnating the silicate with carbolic acid, thymol, or iodine for instance, and passing a current of air through the mass, which for such purpose is conveniently contained in a box or case, the opposite sides of which are perforated, the air then will be incapable of communicating disease germs, however foul it may previously have been. If eucalyptus oil or other odorous substance be substituted for the preceding, the wool will impart an agreeable fragrance to the air currents passing through it. The silicate may be renewed at any time, even if clogged with much dust and organic matter, by simply baking in a hot oven for a short time, and can then, of course, be charged again. Mr. Scott proposes to use these hygienic silicate screens in connection with the doors and windows of hospitals, schools, public buildings, and private dwellings. A form of safety respirator, for the use of nurses and others, on the same principle, is also suggested.

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TABLE OF CONTENTS.

PAGE

I. TECHNOLOGY AND CHEMISTRY.—The India-rubber and Gutta percha Industries.—A valuable series of lectures, London Society of Arts, by THOMAS BOLAS. 4 figures.—I. The sources of India-rubber.—Early manufactures of rubber.—Rubber-bearing trees.—Collection and composition of rubber juice.—Characteristics of rubber.—Contraction of rubber by heat.—Oxidation of rubber.—Action of light on rubber.—Solvents of rubber.—II. Purification of raw rubber.—Quality.—Mastication of rubber.—How rubber toy balloons are made.—Rubber cements.—Rubber gloves. 3959
Piassava Fiber. 3962
An Afghan Jumpan, or Sedan Chair. 1 figure. 3962
Atomic Weight of Glucinum. 3962
Improved Gas Burners. 8 figures. Sugg's improvements in gas burners. 3963
Glass Manufacture. 19 figures. Section of furnace, ovens, moulds, etc. 3964
Manufacture of Cotton Cords. 10 figures. Openshaw's inventions and improvements. 3967
Solvay's Ammonia Water Concentrator. 2 figures. 3969
A New Improvement in Mineral Analyses. 3969
Tin Crystals. Muriate of Protoxide of Tin. 3970
Fireproof Materials. 3970
Destructive Action of Woody Fiber upon Salicylic Acid. By H. KOLBE. 3970
Solution of Chlorine in Water. By M. BERTHELOT. 3970
Fast Shades on Wool. 8 practical receipts for dyeing. 3970
Helvetia Green. 3971
Bleaching Jute. 3971
Method of Determining the Free Fatty Acids Present in Commercial Oils. By M. CARPENTIN. 3971
Black Paper Pulp. By M. AUGUSTE ABADIE. 9 recipes for dark wrapping paper colors. 3971
Preparation of Glycerine from Soap Boilers' Lyes. 3971
Luminous Paint. 3971

II. ELECTRICITY, ETC.—Lightning Conductors. British Association paper. By RICHARD ANDERSON. 3960
On the Proper Form of Lightning Conductors. British Association paper. By WILLIAM HENRY PREECE. 3960
An Electro-Dynamic Paradox. By M. GERARD LESCUYER. 3960

III. PHYSIOLOGY, HYGIENE, ETC.—The Mechanical Labor of One Man.—Food and working force. 3960
Mental Imagery. 3960
Peculiar Alteration of Butchers' Meat. 3963
Carbolized Camphor in Diphtheria. 3974
Hygienic Screens. 39.4

IV. ART AND ARCHITECTURE.—Capitals of Pilasters.—Italian Renaissance. figures. 3964
Suggestions in Decorative Art. 1 figure.—Carved panel ornament. Designed and executed by TH. SCHOOP, Vienna. 3965

V. NATURAL HISTORY, ETC.—The Present Condition and the Future Task of Modern Paleontology. By Prof. CARL VOGT, Geneva. A remarkable study of the paleontological evidence of evolution. 3971
Prophecy of the Weather. By ISAAC P. NOYES. 3973
Observations Regarding Falls of Meteoric Dust in Italy. 3974

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